THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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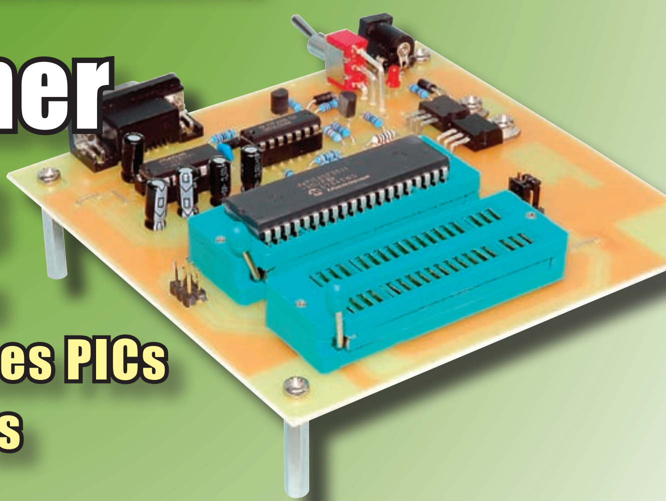
The ultimate sound-to-light system using digital signal processing and dot matrix LEDs

PIC-Based Water Tank Level Meter

Part 2 – Building, calibration and installation

Low-cost programmer for dsPICs and PICs



- Program dsPIC30F series devices
- Adaptor board for 10F and 12F series PICs
- Easy-to-build using standard parts

Plus RECYCLE IT

Getting the good bits from old washing machines

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• PROJECTS • THEORY •
• NEWS • COMMENT •
• POPULAR FEATURES •
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EPE EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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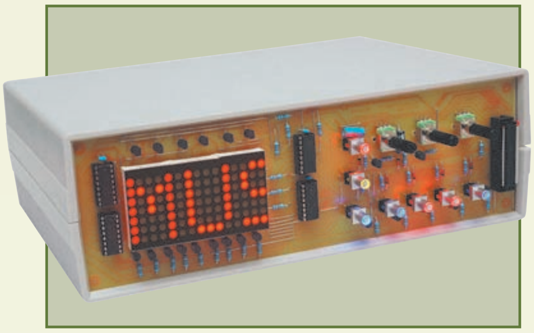
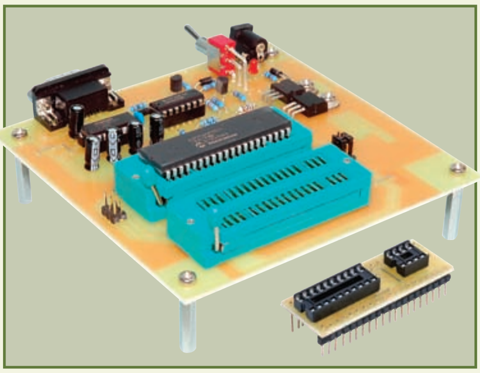




Projects and Circuits

Series and Features

Regulars and Services

Our June 2010 issue will be published on Thursday 13 May 2010, see page 80 for details.

EVERYDAY PRACTICAL ELECTRONICS

FEATURED KITS

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested down under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

May 2010

Jaycar Electronics

WATER TANK LEVEL METER KIT

KC-5460 £31.75 plus postage & packing
This PIC-based unit uses a pressure sensor and displays the tank level via an RGB LED at the press of a button. Add optional wireless remote display panel to monitor up to ten separate tanks (KC-5461) or you can add a wireless remote controlled mains power switch (KC-5462) to control remote water pumps. Kit includes electronic components, case, screen printed PCB and pressure sensor.

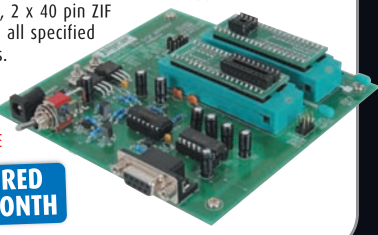
Also available:
KC-5461- Remote display kit £24.75
KC-5462 - UHF remote mains switch kit £29.00

Featured in this issue of EPE

FEATURED THIS MONTH

PIC MICROCONTROLLER SERIAL PROGRAMMER KIT

KC-5467 £21.75 plus postage & packing
This very cost effective programmer kit can handle all the dsPIC30F family and almost all of the regular PICs available in a DIP package. It uses freely available software for PCs and is easy to build. Microchip offers free documentation and source code on their website so getting started should be a breeze. Supplied with screen printed PCB, 2 x 40 pin ZIF sockets and all specified components.



Featured in this issue of EPE

FEATURED THIS MONTH

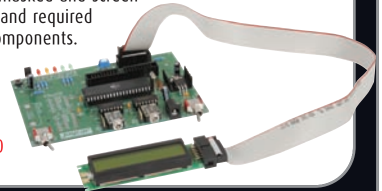
FAST NI-MH BATTERY CHARGER KIT

KC-5453 £12.50 plus postage & packing
Ideal for RC enthusiasts who burn through a lot of batteries. Capable of handling up to 15 of the same type of Ni-MH or Ni-Cd cells. Build it to suit any size cells or cell capacity and set your own fast or trickle charge rate. Features overcharge protection and temperature sensing. Kit includes solder mask & overlay PCB, programmed micro and specified electronic components. Case, heatsink and battery holder not included.

Featured in EPE August 2009

CD-ROM AUDIO PLAYBACK ADAPTOR KIT

KC-5459 £19.00 plus postage & packing
Put those old CD-ROM drives to good use as CD players using this nifty adaptor kit. The adaptor accepts signals from common TV remote controls enabling drive audio functions to be controlled as easily as a normal CD player. Features pre-programmed micro controller, and IDC connectors to the included display panel. Supplied with solder masked and screen-printed PCB and required electronic components.



Featured in EPE Jan 2010

STEREO HEADPHONE AMPLIFIER KIT

KC-5417 £10.25 plus postage & packing
Drives one or two stereo headphones from any line level (1 volt peak to peak) input. The circuit features a facility to drive headphones with impedances from about 8-600Ω. Comes with PCB and all electronic components.

Featured in EPE November 2009

Also recommended:
Box HB-6012 £2.00
Power Supply Kit KC-5418 £6.00

PIC LOGIC PROBE KIT

KC-5457 £5.00 plus postage & packing

Operating on 2.8-15VDC, this logic probe is suitable for use on the most modern circuits. Extremely compact with SMT devices on a PCB only 5mm wide. It's capable of picking up a pulse only 50mS long and will also detect and hold infrequent pulses when in latch mode. Kit includes PCB and all specified electronic components including pre-programmed PIC. You'll need to add your own case and probe - a clear ballpoint pen and a darning needle work well.

Featured in EPE July 2009

EMERGENCY 12V LIGHTING CONTROLLER KIT

KC-5456 £20.50 plus postage & packing
Automatically supplies power for 12V emergency lighting during a blackout. The system is powered with a 7.5Ah SLA battery which is maintained via an external smart charger. Includes manual override and over-discharge protection for the battery. Kit supplied with all electronic components, screen printed PCB, front panel and case. Charger and SLA battery available separately.

Featured in EPE November 2009

RADAR SPEED GUN KIT - MKII

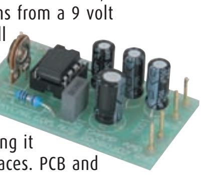
KC-5441 £29.00 plus postage & packing
If you're into any kind of racing like cars, bikes boats or even the horses, this kit is for you. The electronics are mounted in the supplied Jiffy box and the radar gun assembly can be made simply with two coffee tins fitted end to end. The circuit needs 12 VDC at only 130mA so you can use a small SLA or rechargeable battery pack. Kit includes PCB and all specified components. This upgraded version is now even more stable and accurate than the popular original.

Featured in EPE January 2009

POPULAR BEST SELLING KITS

"The Champ" Audio Amplifier

KC-5152 £2.50 plus postage & packing
This tiny module uses the LM386 audio IC, and will deliver 0.5W into 8 ohms from a 9 volt supply making it ideal for all those basic audio projects. It features variable gain, will happily run from 4-12VDC and is smaller than a 9 volt battery, allowing it to fit into the tightest of spaces. PCB and all electronic components included.



SD/MMC Card Webserver In a Box

KC-5489 £26.25 plus postage & packing
Host your own website on a common SD/MMC card with this compact Webserver In a Box (WIB). It connects to the Internet via your modem/router and features inbuilt HTTP server, FTP server, SMTP email client, dynamic DNS client, RS232 interface along with four digital outputs and four analogue inputs. Requires a SD memory card, some SMD soldering and a 6-9VDC power adaptor. Kit includes PCB, case and electronic components.

Jaycar Electronics

Freecall order: 0800 032 7241

4000 Series

4000B	£0.27
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4006B	£0.65
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4011B	£0.16
4012B	£0.16
4013B	£0.18
4014B	£0.30
4015B	£0.27
4016B	£0.20
4017B	£0.26
4018B	£0.25
4019B	£0.25
4020B	£0.25
4021B	£0.22
4022B	£0.38
4023B	£0.23
4024B	£0.22
4025B	£0.20
4026B	£0.67
4027B	£0.21
4028B	£0.21
4029B	£0.38
4030B	£0.17
4035B	£0.31
4040B	£0.24
4041B	£0.31
4042B	£0.19
4043B	£0.35
4046B	£0.42
4047B	£0.25
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4049B	£0.29
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4050B	£0.20
4051B	£0.23
4052B	£0.32
4053B	£0.20
4054B	£0.56
4055B	£0.34
4060B	£0.17
4063B	£0.41
4066B	£0.17
4068B	£0.19
4069UB	£0.18
4070B	£0.15
4071B	£0.20
4072B	£0.25
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4076B	£0.30
4075B	£0.15
4077B	£0.28
4078B	£0.30
4081B	£0.13
4082B	£0.21
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4086B	£0.33
4093B	£0.16
4094B	£0.29
4098B	£0.40
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4511B	£0.30
4512B	£0.27
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4516B	£0.44
4518B	£0.26
4520B	£0.34
4521B	£0.68
4526B	£0.40
4527B	£0.40
4529B	£0.44
4532B	£0.24
4536B	£1.00
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4541B	£0.33
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4556B	£0.40
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74HC04	£0.14
74HC08	£0.17
74HC10	£0.21
74HC11	£0.21
74HC14	£0.18
74HC20	£0.28
74HC27	£0.16
74HC30	£0.22
74HC32	£0.14
74HC42	£0.36
74HC73	£0.40
74HC74	£0.15
74HC75	£0.31
74HC85	£0.23
74HC86	£0.21
74HC107	£0.40
74HC123	£0.33
74HC125	£0.26
74HC126	£0.46
74HC132	£0.26
74HC133	£0.34
74HC137	£0.30
74HC138	£0.26
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74HC173	£0.38
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74HC195	£0.32
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74HC257	£0.25
74HC259	£0.29
74HC273	£0.32
74HC299	£0.61
74HC365	£0.28
74HC367	£0.38
74HC368	£0.29
74HC373	£0.35
74HC374	£0.34
74HC390	£0.37
74HC393	£0.36
74HC563	£0.56
74HC573	£0.27
74HC574	£0.30
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74HC597	£0.22
74HC688	£0.46
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74HC4017	£0.24
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74HC4040	£0.29
74HC4049	£0.31
74HC4051	£0.50
74HC4052	£0.34
74HC4053	£0.22
74HC4060	£0.23
74HC4075	£0.27
74HC4078	£0.32
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74HC4543	£0.90

74LS Series

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74LS01	£0.14
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74LS03	£0.21
74LS04	£0.30
74LS05	£0.14
74LS08	£0.19
74LS09	£0.15
74LS10	£0.27
74LS11	£0.17
74LS12	£0.25
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74LS27	£0.25
74LS30	£0.20
74LS32	£0.23
74LS37	£0.31
74LS38	£0.18
74LS40	£0.14
74LS51	£0.24
74LS83	£0.38
74LS85	£0.48
74LS86	£0.25
74LS92	£0.45
74LS93	£0.44
74LS107	£0.30
74LS109	£0.21
74LS112	£0.24
74LS113	£0.23
74LS114	£0.36
74LS122	£0.31
74LS123	£0.31
74LS125	£0.28
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74LS173	£0.24
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74LS195	£0.24
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74LS251	£0.24
74LS257	£0.24
74LS258	£0.24
74LS266	£0.14
74LS273	£0.32
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74LS367	£0.21
74LS368	£0.21
74LS373	£0.43
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74 Series

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UF4004	£0.08
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1.5A 200V	£0.19
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1.5A 600V	£0.24
1.5A 800V	£0.26
1.5A 1kV	£0.18
2A 100V	£0.34
2A 200V	£0.34
2A 400V	£0.35
2A 800V	£0.36
2A 1000V	£0.45
3A 200V	£0.34
3A 400V	£0.40
3A 600V	£0.33
3A 1000V	£0.33
4A 100V	£0.78
4A 200V	£0.80
4A 400V	£0.86
4A 600V	£0.90
6A 100V	£0.49
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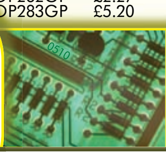

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It could be worse!

I have had my share, perhaps more than my fair share of telecom-related problems over the previous 12 months. Last summer, I was so fed up with the service I received from one provider that I vented my rage in an editorial (see August 2009). Things got better, the problem was solved... eventually, and by and large my phone and Internet connections have done what they say on the tin – more or less. I say 'more or less', because despite a recent upgrade, I can't help feeling that if anything my Internet connection has slowed. It's still pretty good, but not quite the 'Star Trek' experience I had hoped for. Once I've gone to press on this issue of EPE I will do some tests and hopefully sort out the problem.

I am so dependent (professionally) on good web, and especially email access, that I now have a completely independent back up system via my iPhone. I can 'tether' it to my computer via Bluetooth. It's not 'quick' compared to good broadband, but it does the job perfectly adequately. So, with my belt and braces approach, I am about as secure as I can be without spending a fortune. In fact, when I stand back and look at the overall quality and reliability of the combined systems, I am actually pretty spoilt.

This was really brought home to me by an amusing story courtesy of Thomas Scarborough, an Ingenuity Unlimited stalwart who lives in Cape Town, South Africa. He sent us the following news story: http://tinyurl.com/yakemtx. So, next time you have problems, try, however hard it might be, to remember that here in the UK we get a pretty good service, it could be worse – so much worse!

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite) and from all UK newsagents (distributed by SEYMOUR). *EPE* can also be purchased from retail magazine outlets around the world. An Internet online version can be purchased and downloaded for just $18.99US (approx £13) per year, available from **www.epemag.com**

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A number of projects and circuits published in *EPE* employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

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We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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NEWS

A roundup of the latest Everyday News from the world of electronics

TV LED or not TV LED? By Barry Fox

That is the question – according to the Advertising Standards Authority (ASA). They claim the electrically incorrect term 'LED TV' is defaulting into the English language.

OLED TVs are screens made from organic light emitting diodes. But they are small and very expensive. So most companies sell LCD TVs, which use LEDs to back-light the screen, instead of the usual fluorescent tubes.

Last year, Samsung started to promote LED-backlit LCD TVs as 'LED TVs', and after consumer complaints the ASA ruled that the adverts 'implied the TV displays were comprised totally of LEDs... when that was not the case.'

'We considered that because the ads were ambiguous and did not make clear how the TVs utilised the LED technology, the ads were likely to mislead' said the ASA. 'The ads must not appear again in their current form. We told Samsung to ensure that future marketing communications described the technology their products used accurately.', see: **www.bcap.org.uk/asa/adjudications/Public/TF_ADJ_46783.htm**

Since then, Samsung has sent out press releases and posted web publicity which refer to LED monitors and LED TVs, while Samsung's in-store promotion uses a stylised version of the name LED TV, see: **www.samsung.com/uk/consumer/tv-audio-video/television/index.idx?pagetype=type** and **www.samsung.com/uk/consumer/tv-audio-video/television/led-tv/index.idx?pagetype=subtype**

ASA explained its position: 'Advertising is considered to be anything in paid-for space, so on the Internet that will include pop-ups, banner ads and sponsored link searches. While we do not cover displays in-store, we do cover direct marketing leaflets.

'Websites are currently outside of the ASA's remit – when the Internet was first created, websites were originally thought of as online shops and therefore come under the remit of Trading Standards.'

Samsung says it 'will continue to use the term LED as we believe it will continue to be a commonly used industry term (and) is confident that it is not in breach of the ASA ruling.'

So, although Samsung's rivals have so far used more clumsy but more accurate terms like 'LCD TV with LED back-lighting' it can only be a question of time before they too start promoting 'LED TVs'.

Tele Atlas South Africa maps ready for World Cup

Can't miss it now! – the Loftus Versfeld Stadium in Pretoria, as displayed in Tele Atlas

With the World Cup on the horizon, digital maps and dynamic content provider Tele Atlas is now offering its customers a World Cup Soccer-ready digital map of South Africa. The special version of the company's MultiNet map database includes all roads in South Africa, Lesotho and Swaziland, as well as accurate details covering the nine host cities in South Africa. It is the map fans need to find everything they want, from restaurants, hotels and bars to the fastest routes around regulated traffic zones near event locations.

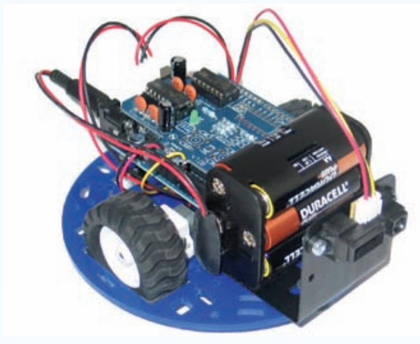
As well as complete coverage of the street network in South Africa, Lesotho and Swaziland, including more than 700,000 kilometers of roads and 240,000 points of interest (POIs). The special World Cup version adds 12,000 kilometers of new roads with speed restriction, signpost and lane information. It also offers World Cup Soccer specific information such as:

- *Fan park areas where people gather to support specific teams with big screens and special events*
- *Park and Ride, car parking points around the stadiums where fans can take public transport to and from the stadium gates*
- *Security check zones, specific places around stadium entrances where security checks will take place*
- *Stadium gate information, pedestrian routes*
- *Regulated traffic zones showing temporary closures during competitions.*

The new MultiNet also contains more than fifty 3D landmarks and landmark icons of important buildings and stadiums across the host cities, helping visitors to see exactly where they are and to easily find services.

Also included in this product release are Tele Atlas Advanced City Models of Johannesburg, Cape Town Pretoria and other metropolitan areas, offering three-dimensional representations of cities.

RobotBits launches new Arduino-based robot kit



RobotBits has launched a new robot kit based around 'Arduino', the popular open-source electronics prototyping platform.

The new robot kit includes an Arduino Duemilanove 328, motor driver 'shield' and all the electrical and mechanical components needed to build a complete mobile robotics platform for fun, research and education.

The kit is available in three build levels, including a 'no-solder' kit and 'fully assembled' forms. The robot is also complimented by a new selection of sensor options and mounting hardware designed for applications such as line following, room mapping and obstacle avoidance.

Prices start at £76.59+VAT for the basic kit (without sensors). You can find out more about the kits at: **www.robotbits.co.uk**.

CONSUMERS AT RISK OF BROADBAND 'FAIR USAGE' PENALTY FINES

The Internet has dramatically changed the way we live our lives, allowing us to shop, gamble, watch TV and even date online. As a result, Internet service providers (ISPs) have introduced 'fair usage' policies and download limits designed to ensure all users experience a reasonable connection speed.

However, with applications such as BBC iPlayer becoming more popular, the stress placed on the average broadband connection is greater than ever – meaning consumers have to be very careful not to fall foul of their ISP's rules.

A recent survey of 1,400 broadband users has highlighted the lack of understanding surrounding fair usage policies and download limits and what they mean for consumers:

- A fifth (20%) had no idea what the terms of their download limit/fair usage policy was
- Almost a third (29%) said their ISP's traffic management policy was not explained at point of sale
- 42% did not know how much online content they downloaded every month, highlighting how easy it can be to inadvertently break their ISP's rules.

Michael Phillips, product director at **Broadbandchoices.co.uk** commented:

"Fair usage policies and download limits are fast becoming the next big grievance between consumers and ISPs, and this is mainly due to a lack of understanding around the issue. The streaming of online content, whether it is TV shows, video clips or music files, will only continue to increase, and the rules governing this area need to adapt to take into account the changing nature of Internet usage."

Broadbandchoices top tips for safe downloading are:

- Pick the right ISP – some providers like Be Broadband or O2 Broadband are designed with heavy downloaders in mind. Although their 'unlimited' packages come with fair usage policies attached, both ISPs are more generous with their allowances than most. Both Virgin Media and Sky have top of the range packages with no restrictions at all.
- Download at night – traffic shaping, which slows down a broadband connection, is applied by many providers during peak hours during the evening. Therefore, broadband users who download at night – usually from midnight onwards – should find their music and movie files download a lot quicker. Some packages, like PlusNet's Pro plan, offer free overnight downloading.
- Turn off your peer-to-peer – some programs use peer-to-peer software to share files faster between users. However, simply closing them will let them continue to run in the background, uploading files to the sharing network. This not only slows a connection down, but will also eat away at your download allowance as uploading also counts against usage limits. Make sure that you fully exit the program each time you close it, and use your task manager to check that it's not still running.
- Track your usage – if you have a set download limit, or you're concerned about exceeding your fair usage allowance, then installing a free broadband download monitor is a great way of tracking your downloads, and you can even set alarms to alert you as you near your limit.

Bletchley Park Trust launches 2010 programme of events

Bletchley Park, home to the codebreakers of World War Two, has launched its 2010 programme of events, which includes a range of fun-filled and action-packed activities to suit everyone, from families and computer geeks, to film buffs and plane spotters! As well as many of the old favourites, new events for this year include a Vintage Computer Fair, Armed Forces Day and Golden Age of Cinema. As in previous years, the Battle of Britain Memorial Flight squadron will be supporting Bletchley Park with a number of flypasts to coincide with different events in their ever-popular Spitfires, Hurricanes *and* Lancasters.

The UK's first ever Vintage Computer Festival *will be held in The National Museum of Computing at Bletchley Park on 19 and 20 June. Enthusiasts and collectors from across Europe are expected to enjoy the many exhibitions, demonstrations, flea market and auction, and a number of special talks and presentations. Kevin Murrell, trustee at the National Museum of Computing, describes the event as "The ultimate geek version of the Antiques Roadshow!"*

Coinciding with the 70th anniversary of Churchill's appointment as Prime Minister in 1940, the joint Enigma Reunion and Churchill Weekend take place on 4 and 5 September. During the event, visitors will have the unique opportunity to mix with and talk to men and women who worked at Bletchley Park during the war. The Park's annual Blitznight firework display takes place on 6 November and the year is rounded off with the Remembrance Day Parade on 14 November.

Entrance to all events (except Blitznight) is included in the price of Bletchley Park's annual £10 season ticket, which following the first visit, entitles the holder to receive free entry to the Park for 12 months.

Two-letter .uk domain names to be allowed

The current rules for registering .uk domain names do not allow the registration of two-letter domain names. However, Nominet has now announced that it is planning to release two-letter, one-character and other reserved .uk domains.

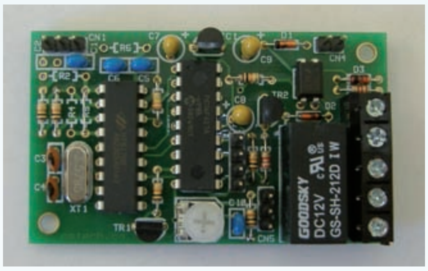
Nominet is the organisation that maintains the register of .uk domain names and runs the technology which locates a computer on the Internet hosting the website or email system you're looking for when you type in a web address or send an email to an address that ends in .uk.

Toshiba turns the (incandescent) lights out

Japanese electronics giant Toshiba has ended production of general-use incandescent bulbs, a product which Toshiba was first to manufacture in Japan and that it has produced for 120 years. Toshiba decided to focus on environmentally friendly lighting in 2008, and since then has been advancing a transition to new lighting products, particularly LED lighting.

From an initial production of only 10 bulbs a day in 1890, production climbed to a peak of 78 million a year, and cumulative shipments to date add up to over four billion bulbs.

CS Technology offers DTMF decoder kit



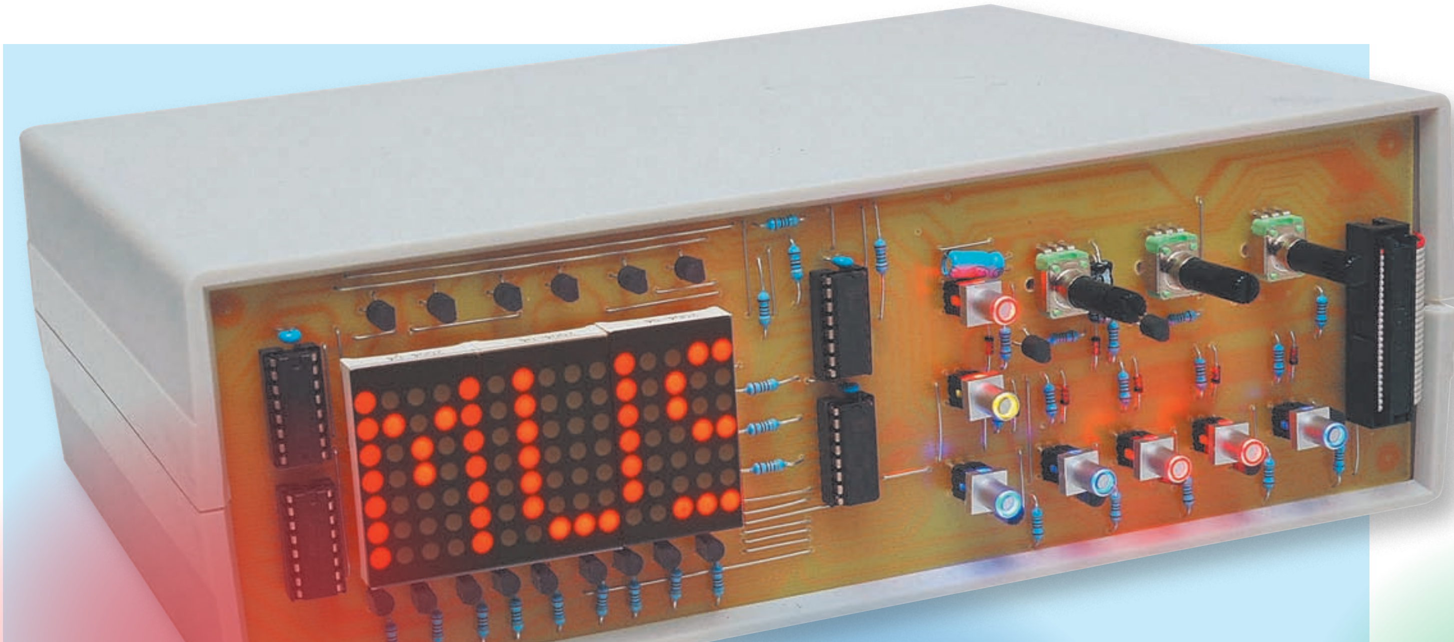
CS Technology Ltd have just added a new DTMF decoder kit to their range, the new kit includes on-board relay and an opto-coupled input.

The relay can be switched on/off or pulsed under DTMF control with/without a four-digit PIN, and both the relay state and the opto input can be interrogated with Morse response.

The complete kit of parts is just £15.99 from their website at: **www.cstech.co.uk**.

New material heralds electronics revolution

The pace of materials science in electronics continues to astound and inspire engineers across the globe. Now, a promising new product has stolen an astonishing lead on germanium, silicon and even gallium-arsenide. The great advantage of this new 'wonder' concoction is that not only is it based on readily available elements – principally a compound of carbon, hydrogen and oxygen – but that engineers have determined polluting waste disposal is 'simply not an issue'. Due to be launched just after 31 March this year, *EPE* has obtained photographs of advanced prototypes, visit: **http://tinyurl.com/37o2w2**.



Part 1: By MAURO GRASSI

Run your own disco light show with the amazing, versatile

DSP Musicolour

This DSP Musicolour accepts audio input signals and drives coloured lights 'in tune' with the music. Its four output channels respond to different audio frequency bands, and the brightness of the lights is in direct proportion to the amplitude of the frequency components. A dot-matrix LED menu display is featured on the front panel, and this also functions as a spectrum analyser or VU meter.

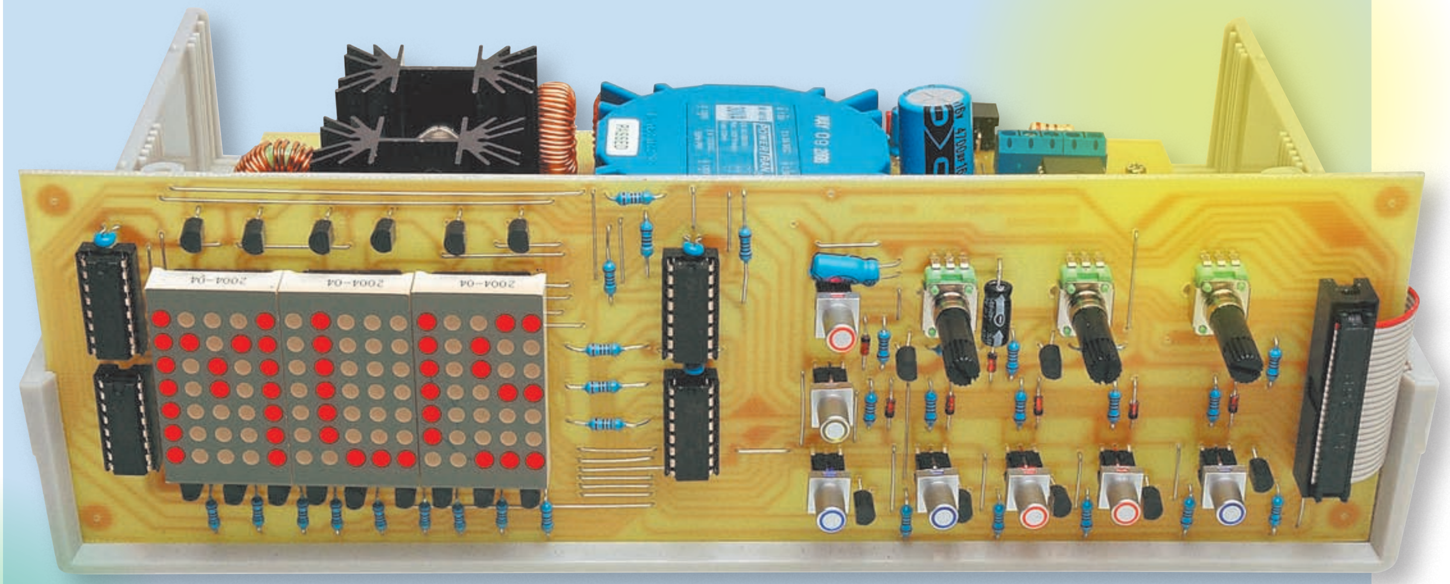
IN PRESENTING this brand new project, we are reviving a name which became synonymous with party and disco light shows in the 1970s and 1980s. Long-time readers may be familiar with the 'light shows' presented in the many 'Electronics' magazines of that period.

Nearly all of these projects were analogue designs, based on op amps and logic ICs. The audio was passed through different pass-band filters for each channel, and the filtered outputs were used to drive either phase-controlled triacs or power MOSFETS in switch mode.

The logic ICs were also used to produce chaser modes, which were alternating patterns controlling the output channels in the absence of an audio input. These chaser modes meant that you could have pleasing lighting effects without any music.

Two decades on, we now present the DSP Musicolour, a full digital design using DSP (digital signal processing). It is based on a single DSP microcontroller to produce a comprehensive list of features that were simply not possible with previous analogue designs.

The DSP Musicolour operates from 230V to 240V AC or 115V to 120V AC mains (detecting the 50Hz or 60Hz mains frequency automatically) and drives four channels of incandescent lights. The total power output rating is 2400W for the 230V to 240V AC 10A version and 1600W for the 115V to 120V AC 15A version. For the 240V AC



This photo and the photo on the facing page show the completed DSP Musicolour boards fitted to the case. The displays have been lit by temporarily powering the Display Board using an external DC supply.

version, each channel is rated at 800W maximum (as long as total power is less than 2400W). For the 120V version, each channel is rated at 400W.

By making the design suitable for both 230V to 240V AC and 115V to 120V AC 50/60Hz mains supplies, we are ensuring that the DSP Musicolour can be built in any part of the world without modifications, apart from changing the power transformer's primary connections.

Operating features

Pictured in this article is the prototype DSP Musicolour without its front or rear panels. The photos show the quite complex vertical PC board which accommodates a 7×15 (rows × columns) dot-matrix LED display, an array of illuminated pushbuttons and three potentiometers. By contrast, the main PC board is larger, but not as packed with components. It carries the microcontroller and the 240V AC triac circuitry.

The pushbuttons are used to navigate through the menus, which are displayed on the dot-matrix display. This display can also be switched to function as a spectrum analyser or as a VU meter, or can be used to display 'screen saver' patterns.

One potentiometer on the front panel is used to vary the screen brightness, screen refresh rate, the frequency band, the gain and the quiescent current of each output channel, among other settings. The other two potentiometers are used to independently control the input sensitivity of each channel. It is then possible to mix the two channels in software before processing the audio data or to select either channel independently as the audio input.

The back panel carries an IEC male mains socket (with an inbuilt mains switch and fuse) plus four 3-pin 240V AC sockets for the four output channels (these are used to connect the lights). It also carries a 4-way speaker terminal block to accept two audio input channels, an optional connector for an external microphone and an optional 10-way IDC connector that can be used to update the firmware (more on this in a later article).

Block diagram

The block diagram of the DSP Musicolour is shown in Fig.1. As can be seen, there are three audio input channels. Two audio channels come from the 4-way speaker terminal block on the back panel, while the third channel is for an onboard electret microphone or an optional external microphone.

The two audio channels pass through the front panel potentiometers and are then fed into independent AC-coupled inverting amplifiers. The output of each amplifier is then fed to a dsPIC microcontroller at inputs AN1 and AN2, and are converted to digital signals by onboard ADCs (analogue-to-digital converters).

Similarly, the microphone signal is fed to an AC-coupled inverting amplifier and the output is again connected to the microcontroller, this time at AN3. Note that the optional third audio input for connecting an external microphone is mixed with the output of the onboard electret microphone.

The two audio channels are independent and, as mentioned earlier, have separate sensitivity controls. They can be optionally mixed in software in different proportions (selectable balance). So there are three distinct audio channels: the two audio channels and the microphone channel.

The audio channels are converted to digital format by onboard ADCs in the dsPIC microcontroller. These are each sampled at around 48kHz (slightly higher than double the highest audible frequency) in order to avoid aliasing.

Next, the resulting digital time domain data is transformed to the frequency domain using an FFT (fast Fourier transform) algorithm. The result is a list of amplitudes for the frequency components of the audio input signal. The computed frequency amplitudes are then used to drive the four output channels via phase-controlled triacs in the output stages. These triacs are driven via optocouplers, which ensure full mains isolation for the low voltage sections of the circuit.

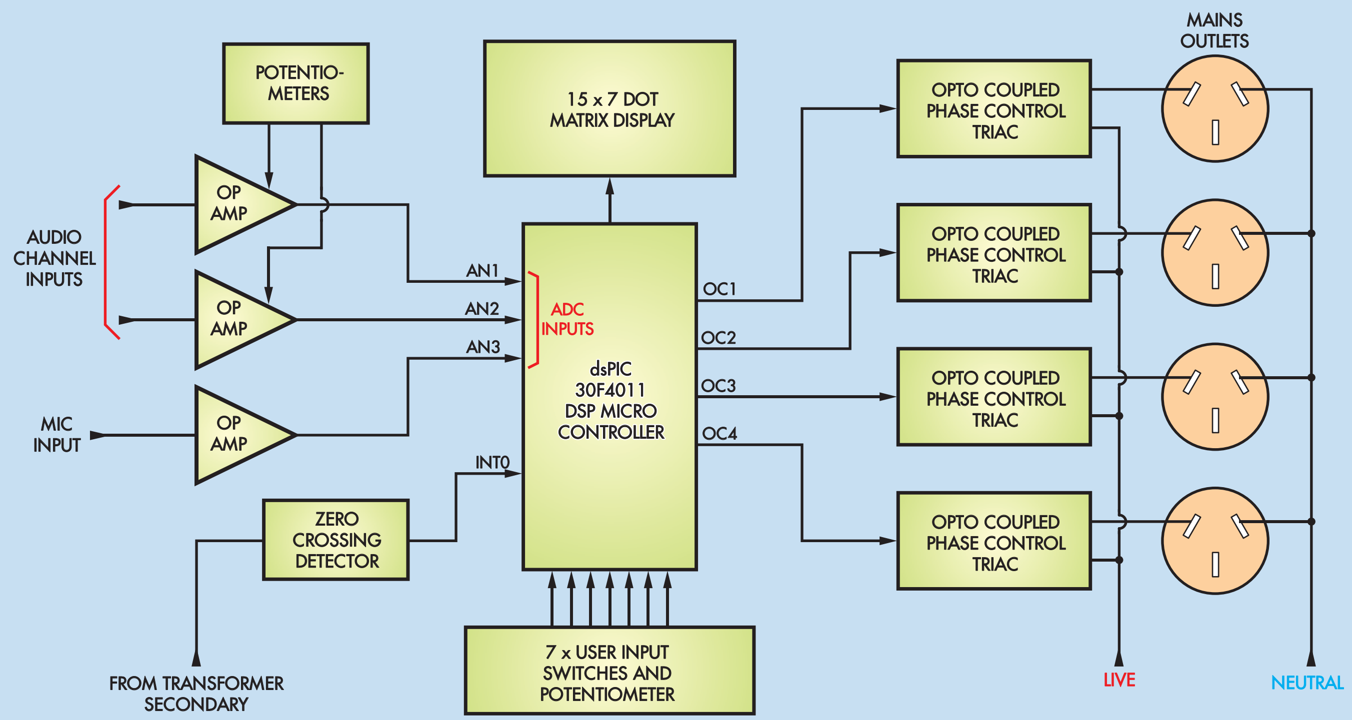


Fig.1: the block diagram of the DSP Musicolour. The audio inputs are digitised and processed using a dsPIC micro-controller to produce control signals for four frequency bands. The dsPIC then phase controls four optocoupled triac output stages to power the mains outlets.

User-selectable

It may be apparent from the description so far that there are no op amp filters, so the frequency bands for each channel are user-selectable. Furthermore, different arithmetic operations can be applied to the digitised audio data to amplify or attenuate it.

This means that each input channel is effectively post-amplified in software. Moreover, the various input channels can be selected and mixed in software with different weighting. In previous designs, the switching was accomplished using a toggle switch.

Providing chaser modes is also much easier with a digital design. Again, it's all done in the software and no extra circuitry is involved.

Circuit operation

Let's now look in more detail at the circuit operation of the DSP Musicolour. The full circuit details are shown in Fig.2 to Fig.5. It's based on microcontroller IC1, a dsPIC30F4011 from manufacturer Microchip. This combines most of the common peripherals of a PIC with a high-performance RISC (reduced instruction set computer) processing core that has instructions optimised for digital signal processing (DSP).

The Microchip dsPIC series of microcontrollers incorporate DSP features like MAC (multiply accumulate), variable bit shifting, bit-reversed addressing modes, dual data fetching (multiple operands), high-precision arithmetic operations (including fractional hardware divide and multiply) and multiple 40-bit accumulators. All DSP instructions are single cycle, meaning the dsPIC series is surprisingly powerful, with throughputs in the tens of MIPS (millions of instructions per second).

In this design, IC1 runs off an internal system clock operating at about 29MHz. Among other things, it's responsible for digitising the audio inputs; processing the audio inputs (including computing the FFT); synchronising with the mains frequency and implementing real-time phase control; driving the multiplexed LED display and responding to key presses. The operation of the software is explained in greater detail later in this article.

Output stages

The output stages of the DSP Musicolour have been uprated using heavy-duty BTA41-600B triacs. **These are isolated-tab triacs rated at 600V, with continuous current ratings of up to 40A and a surge current rating of close to 400A.**

This high surge-current rating is necessary in order for the triacs to withstand the large fault currents which can occur if a 150W floodlight blows its filament. This is a particular problem if the floodlight is facing upwards. In that case, the broken filament can flail around and short to the adjacent filament support. The resulting arc continues until the stem fuse inside the lamp blows.

In addition, the software programmed into the dsPIC has a facility to set the filament preheat current of each output channel. This helps minimise surge currents to protect the lamps.

Note that the four triacs, which are housed in TOP3 packages, are mounted in pairs on the main board and each pair shares a heatsink. These heatsinks are necessary, as the triacs will get hot during normal operation, even if each channel is only rated at 800W.

Each triac is triggered by the dsPIC via a MOC3021 optocoupler (OPTO1 to OPTO4), to ensure full mains isolation from the low voltage part of the circuit. As shown, IC1's 'output compare' pins (OC1 to OC4) are used to drive the internal LEDs of the optocouplers, which then switch on the triacs until the next zero crossing of the mains waveform.

Following the triacs, each channel output has a filter network consisting of a 100μH inductor (rated at 5A) and a 0.1μF 250V AC capacitor, to reduce EMI. As can be seen, the mains live is connected to the A2 terminal of each triac and is switched through to the mains output sockets via the 100μH inductors – see Fig.3. The outputs are then fed to screw terminal blocks CON4 and CON5 on the main board.

Main Features

- Full digital design using a DSP microcontroller (dsPIC)
- Powered from 230V to 240V AC or 115V to 120V AC mains with auto-detection of mains frequency
- Four phase-controlled output channels (8-bit resolution)
- Optocoupled triac triggering for complete isolation of control circuitry from output circuitry
- Zero voltage switching of triacs for minimum RF interference
- Four mains outputs rated at 800W each (240V AC) or 400W (120V AC)
- Selectable gain plus selectable minimum and maximum frequencies for each output channel
- Selectable filament preheat current for each output channel
- Persistent software settings
- Self-diagnostics
- Chaser modes
- Direct stereo inputs for audio modulation of lights
- Microphone input/third channel input for audio modulation of lights
- 7x15 pixel dot-matrix LED display for menus
- Dot-matrix display can function as a spectrum analyser, screen saver or VU meter
- Software-controlled input selection with software mixing
- Adaptive potentiometer control for software settings
- Optional provision for ICSP (in-circuit serial programming)

Audio inputs

As shown in Fig.2 and Fig.4, the two audio channels are fed in via pins 2 and 4 of CON2, and are attenuated by two 270Ω resistors. These resistors ensure proper attenuation of the incoming signals, which are derived from the loudspeaker outputs of an amplifier.

From there, the signals are fed to pins 5 and 6 of connector CON1, and then to pins 5 and 6 of CON7 on the display board (CON1 and CON7 are connected via a 26-way flat-ribbon cable). The audio signals are then further attenuated using potentiometers VR1 and VR2 on the display board and fed back to pins 4 and 3 of CON1 on the main board. These pots set the input sensitivity for the audio channels.

Link LK4 is optional and allows the two audio channels to be mixed together via the 270Ω input resistors. It's normally left out of circuit.

The outputs of VR1 and VR2 (at pins 3 and 4 of CON1) are AC-coupled to op amps IC2a and IC2d via 68nF capacitors and 33kΩ series resistors. These two op amps are wired in inverting mode and operate with a gain of 0.3, as set by their 10kΩ feedback resistors and 33kΩ input resistors (ie, 10kΩ/33kΩ = 0.3).

Because the circuit operates from a single +5V supply rail, the non-inverting inputs of IC2a, IC2d and IC2c (pins 3, 12 and 10 respectively) must all be biased to half supply (Vcc/2). This is achieved using op amp IC2b. Two 10kΩ resistors are wired as a voltage divider to derive a 2.5V reference, and this is fed to pin 5 of IC2b, which is connected as a voltage follower. IC2b's pin 7 output then provides the Vcc/2 (ie, 2.5V) rail to bias the remaining op amps.

IC2c is used to amplify the signal coming from the on-board electret microphone. It's also wired as an inverting amplifier, but operates with a gain of 30. As before, the signal is fed to the op amp via a 68nF capacitor and 3.3kΩ resistor.

Power for the electret microphone is derived from the +5V rail via 1kΩ and 4.7kΩ resistors, while a 47μF capacitor filters this supply.

In addition, the signal from an external microphone can be fed to IC2c via pin 3 of CON2. In that case, the signals from the two microphones will be mixed and applied to IC2c.

The outputs of op amps IC2a, IC2d and IC2c are connected to the ADC inputs of microcontroller IC1 (AN1, AN2 and AN3). Another ADC channel (AN0) is used to read the value of potentiometer VR3, which is also on the display board. This 10kΩ linear potentiometer is used to change settings.

Resetting the micro

Each time power is applied to the circuit, the $\overline{\text{MCLR}}$ (reset) input of IC1 is pulled high (ie, towards the +5V rail) via diode D8 and a 1kΩ resistor. This releases the reset on the dsPIC30F4011 so that it can start operating.

Note that pulling the $\overline{\text{MCLR}}$ input low resets the microcontroller, but this is not used in this circuit. Instead, an internal POR (power on reset) circuit resets the microcontroller when power is first applied.

Diode D8 is included because the $\overline{\text{MCLR}}$ line connects to 10-way IDC connector CON3. This connector is optional, and it is included to allow ICSP (in circuit serial programming). Since the $\overline{\text{MCLR}}$ pin is multiplexed with the programming voltage (Vpp) for ICSP, and because the typical level used is around +13V (much higher than +5V), D8 is reverse biased during ICSP and thus protects the circuit from over-voltage.

LED8 is used as a 'normal function' indicator for the microcontroller, and is normally lit. It may also be used by future software versions to indicate runtime errors in the program. The 470Ω resistor limits the LED current to about 10mA. Note that this LED is mounted on the main board and is not visible with the case lid on.

Links LK5 and LK6 are used to set IC1 so that it operates according to the audio input mode set using LK4 (more on this in a future article). The default configuration is to omit LK4 and LK6, and to install LK5.

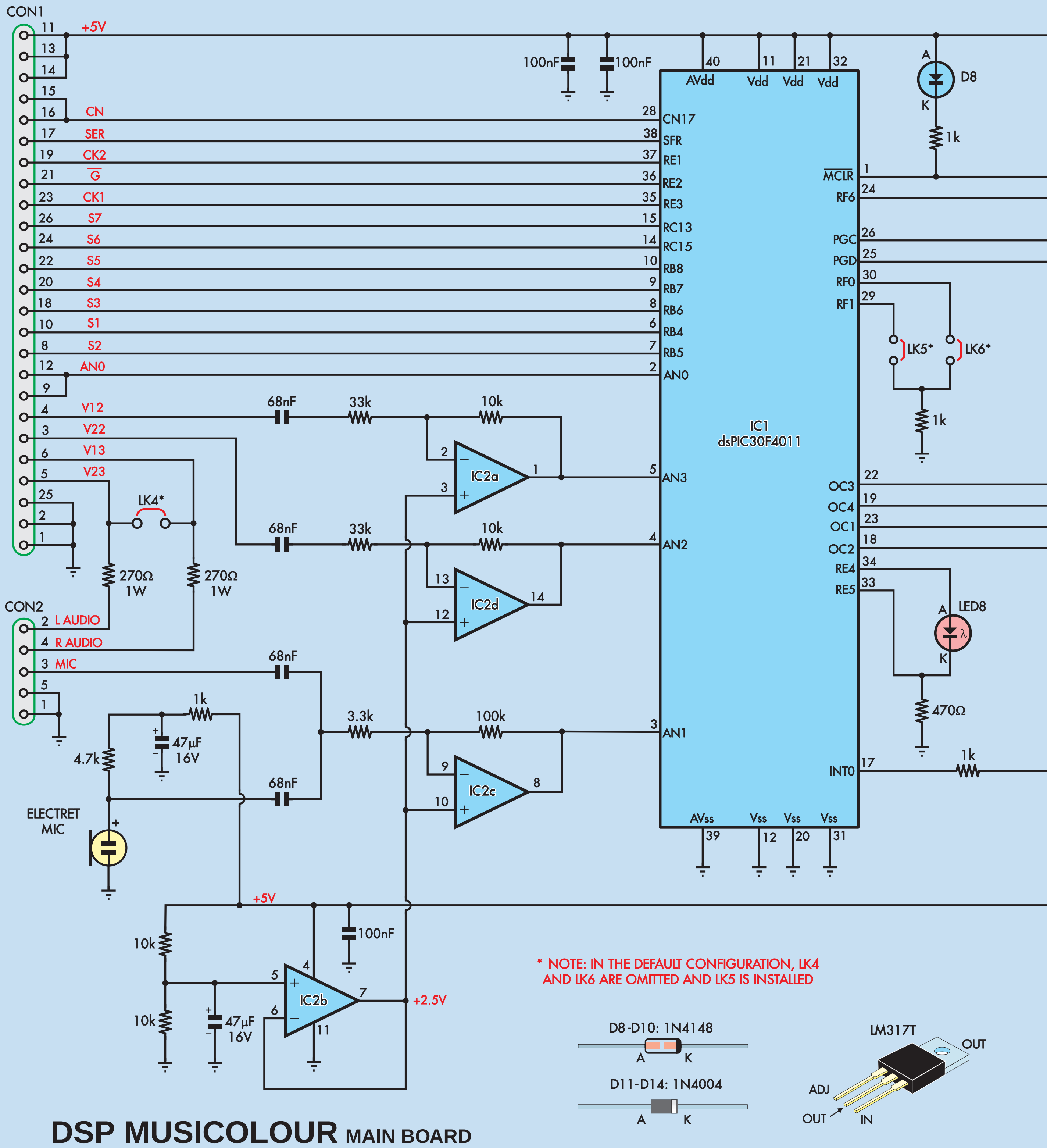
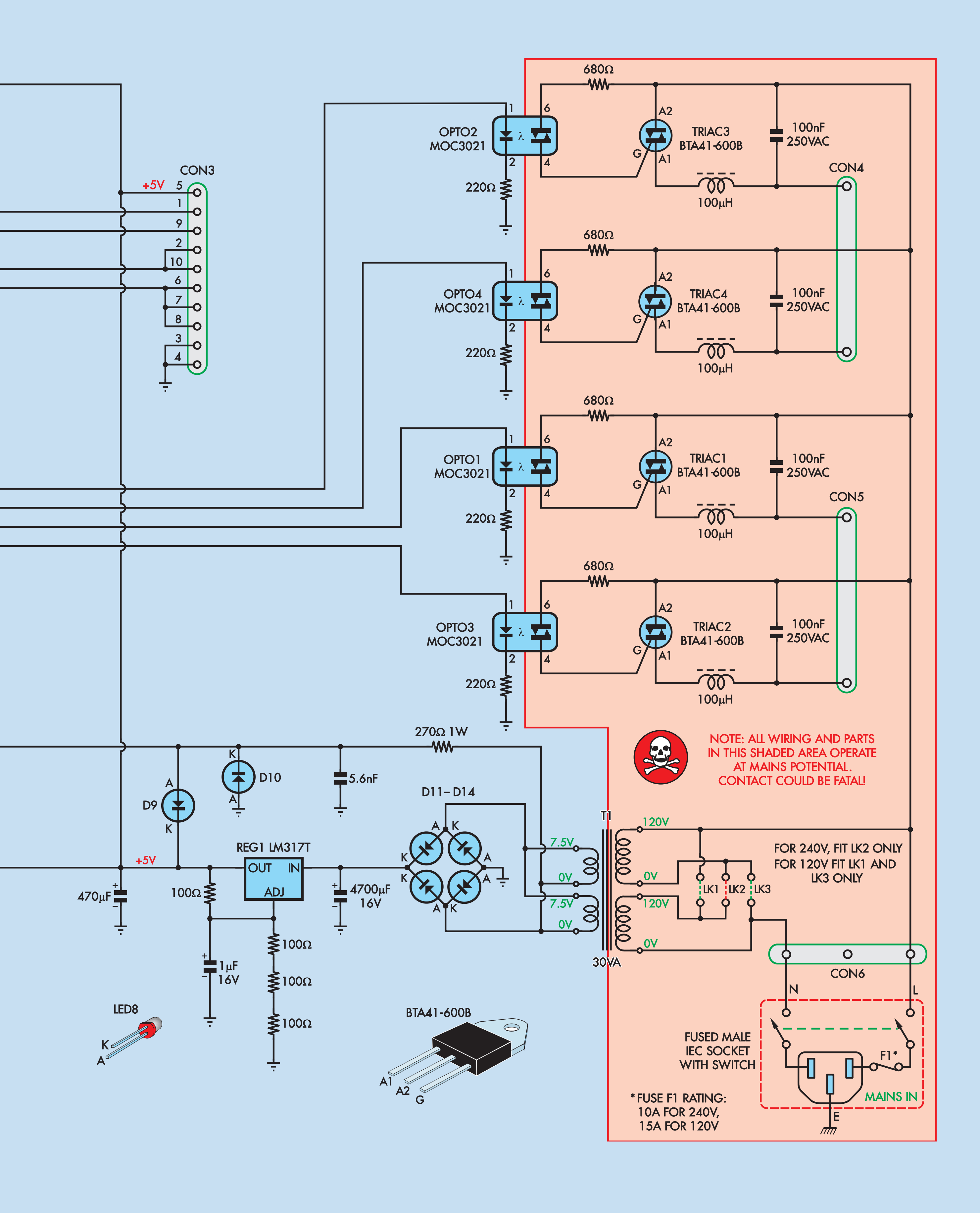


Fig.2: the Main Board circuit. Microcontroller IC1 accepts audio inputs from op amps IC2a, IC2d and IC2c, processes the signal and drives the four triac output stages via optocouplers OPTO1 to OPTO4. It also drives the Display Board via CON1, and processes the inputs from the various controls on this board.



680Ω
OPTO2
MOC3021
TRIAC3
BTA41-600B
100nF
250VAC
CON4
100µH
220Ω
CON3
+5V
OPTO4
MOC3021
TRIAC4
BTA41-600B
OPTO1
MOC3021
TRIAC1
BTA41-600B
CON5
OPTO3
MOC3021
TRIAC2
BTA41-600B
270Ω 1W
D10
5.6nF
D9
D11–D14
NOTE: ALL WIRING AND PARTS IN THIS SHADED AREA OPERATE AT MAINS POTENTIAL. CONTACT COULD BE FATAL!
T1
120V
7.5V
0V
FOR 240V, FIT LK2 ONLY
FOR 120V FIT LK1 AND LK3 ONLY
LK1
LK2
LK3
REG1 LM317T
OUT
IN
ADJ
470µF
100Ω
4700µF 16V
1µF 16V
30VA
CON6
N
L
LED8
BTA41-600B
A1
A2
G
FUSED MALE IEC SOCKET WITH SWITCH
F1*
MAINS IN
E
*FUSE F1 RATING: 10A FOR 240V, 15A FOR 120V

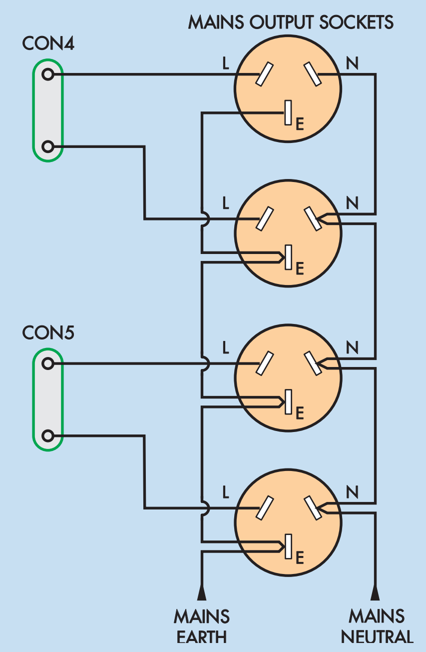


Fig.3: the switched live lines from CON4 and CON5 are connected to the mains outlet sockets as shown here.

Display board circuit

Now let's take a look at the display board circuit (Fig.5). It's based on three 74HC595 shift registers (IC3 to IC5) which are used to drive the 7×15 dot-matrix LED display in multiplexed fashion. This display is actually made up using three separate 7×5 dot-matrix red LED modules (Kingbright TA12-11EWA).

IC3 and IC4 are cascaded to form a combined 16-bit shift register. This is controlled by the CK2 (clock), $\overline{G}$ (enable) and SER (data) lines coming from microcontroller IC1. By using these three lines, any 16-bit value can be loaded into the shift register.

In operation, the 16-bit shift register drives the 15 columns (ie, the anodes) of the 7×15 dot matrix display. The remaining column output, at pin 7 of IC4, is used to drive transistors Q16 to Q22. These in turn drive LED1 to LED7, which are inside the tactile switches (S1 to S7).

Display drivers

In greater detail, the first 15 bits of the combined shift register drive *PNP* transistors Q1 to Q15 (all BC327s) via 470Ω resistors. These transistors are necessary to provide the high currents required to obtain a display that is bright enough. Because the display is multiplexed, each LED is only switched on very briefly, and therefore must be driven quite hard.

Note that there are no series resistors to limit the current. That's because the switching occurs very briefly, and this limits the currents and protects the display modules. In addition, the cathodes are driven by a ULN2003 Darlington array (IC6) and this also limits the total peak currents.

The Darlington transistors inside IC6 are driven by the remaining shift register (IC5). This is controlled in a similar way to the 16-bit register, and is clocked using the CK1 (clock) line from the microcontroller. The $\overline{G}$ (enable) and SER (data) lines are shared with the other two shift register ICs.

Using a separate clock ensures that IC5 can be controlled independently of the two cascaded shift registers. IC5 thus functions as an independent 8-bit shift register and is used to drive the seven rows (R0-R6) of the dot matrix display via IC6. The extra bit is not used.

The seven rows of the display are all cathodes, and the ULN2003 (IC6) is necessary to provide the required current drive. In operation, this device can sink up to 500mA for each of its seven outputs. It's also used to drive the 'extra' row formed by the seven LEDs inside the tactile switches (LED1 to LED7) – ie, IC6 drives the cathodes of LED 1 to LED7, while pin 7 of IC4 switches their anodes.

During the display update period, the microcontroller sends the $\overline{G}$ (enable) line high and this forces all the shift register outputs to also go high. This effectively blanks the display, but this blanking interval is so short that it is imperceptible. The SER (data) line feeds the data from the microcontroller into the shift registers during this blanking period.

Note that because the display is multiplexed, the microcontroller can control the 7×15 dot-matrix display and LED 1 to 7 using just four digital outputs, ie, CK1, CK2, $\overline{G}$ and SER.

Switches S1 to S7 are all pushbutton momentary-contact types. These switches are used to change the operating modes and drive the menus (more on this next month).

In practice, each switch is connected to a separate microcontroller input (via CON1 and CON7) and these seven inputs are all normally pulled high (ie, to +5V) by 1kΩ resistors. The other side of each switch is connected to ground, and the switch contacts are debounced by the software.

Diodes D1 to D7 and their associated 1kΩ pull-up resistor form a 7-input AND gate. Its output (at the anodes) connects to the CN17 (pin 28) input of the microcontroller. This input is used to trigger an interrupt when it changes state, and is used by the software to respond to switch presses.

Power supply

Now let's go back to Fig.2 and describe the power supply.

As shown, power for the low-voltage side of the circuit is derived using a 30VA mains transformer with dual primary and secondary windings. The two primary windings are either connected in series or in parallel, depending on the mains voltage (either 240V AC or 120V AC, respectively).

For a 240V AC supply, LK2 is fitted to connect the primary windings in series. Alternatively, for a 120V AC mains supply, LK1 and LK3 are fitted to connect the windings in parallel. The selected links are soldered to the main PC board, before the transformer is installed.

The incoming mains voltage is fed in by a fused male IEC socket. For 230V to 240V AC mains, this fuse should be rated at 10A, while for 115V to 120V mains, it should be rated at 15A.

The two 7.5V AC secondary windings are connected in parallel and feed a bridge rectifier comprised of diodes D11 to D14, which are standard 1N4004 types. The rectified output of the bridge is then filtered using

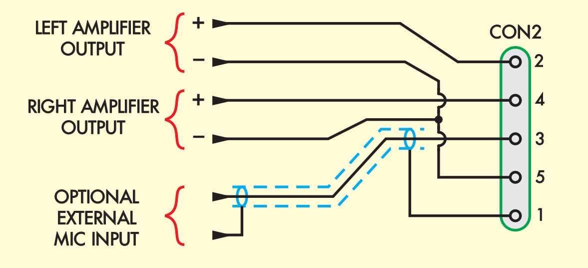
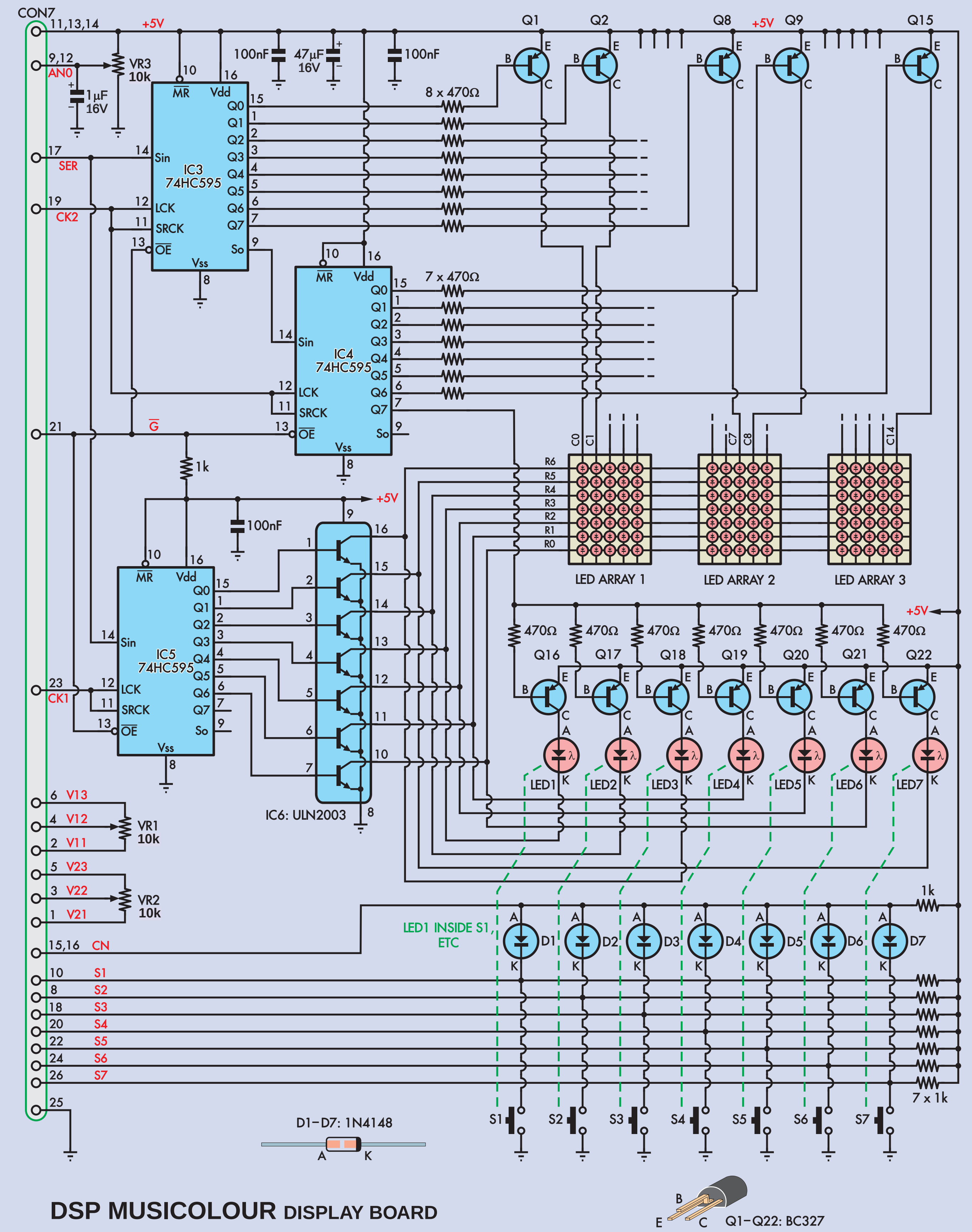


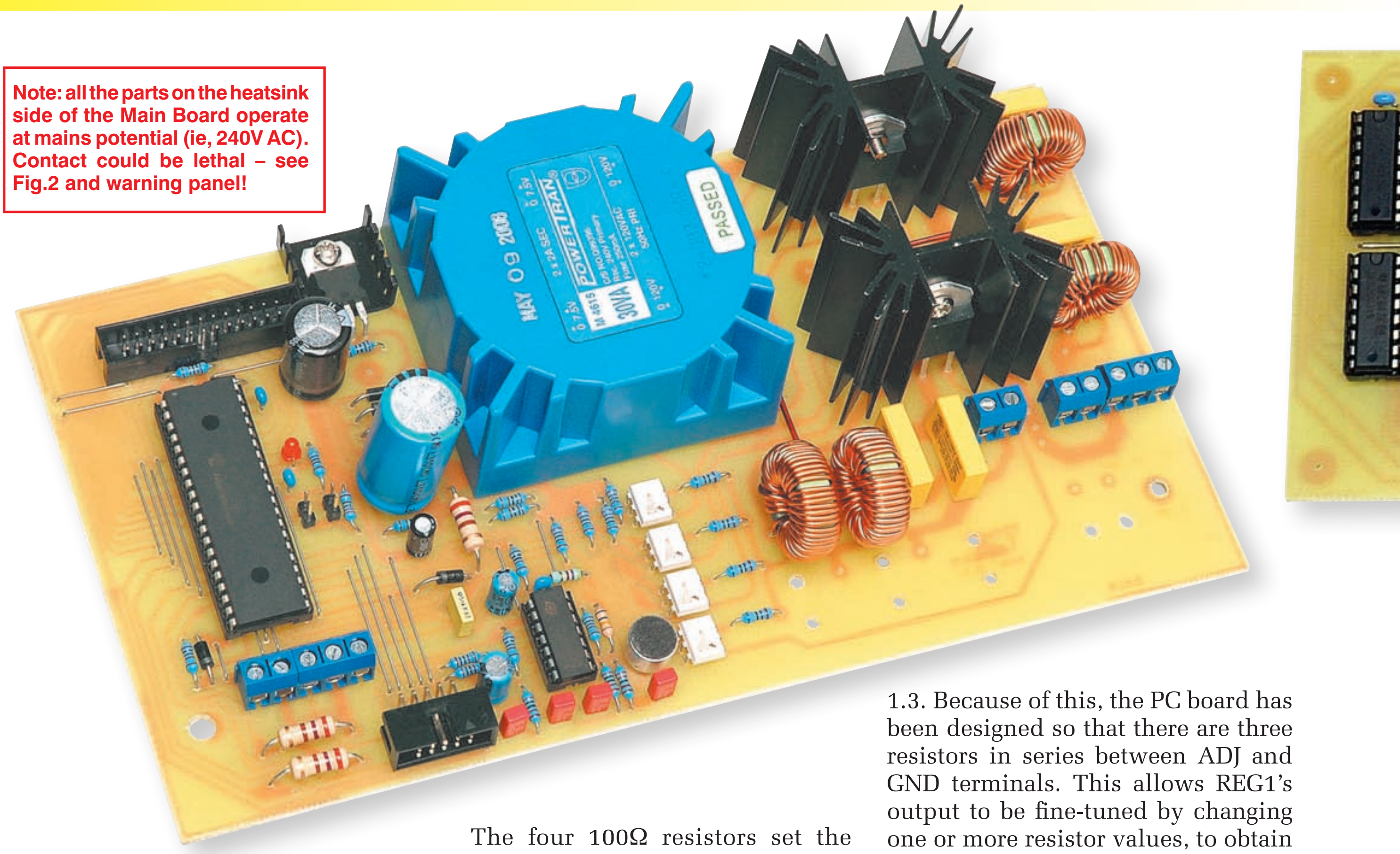
Fig.4: the left and right audio input signals are derived from the speaker terminals of an amplifier and fed in via connector CON2. The external microphone input is optional.



DSP MUSICOLOUR DISPLAY BOARD

Fig.5: the Display Board circuit uses three 74HC595 shift registers (IC3-IC5) to drive the dot-matrix LED displays and the LEDs inside the switches in multiplexed fashion. These shift registers are driven by the dsPIC microcontroller via CON7 using just four digital outputs. Switches S1 to S7 select the various operating and display modes.

Note: all the parts on the heatsink side of the Main Board operate at mains potential (ie, 240V AC). Contact could be lethal – see Fig.2 and warning panel!



a 4700μF capacitor and fed to an LM317T variable-voltage regulator (REG1) to derive a regulated +5V rail.

This +5V rail is used to power the low-voltage section of the circuit, including the op amps, the microcontroller and all the display circuitry. An LM317T was used instead of the common 7805 +5V fixed regulator because it can supply greater current (up to 1.5A).

The four 100Ω resistors set the output voltage from the regulator according to the formula:

$V_{OUT} = 1.25 \times (1 + R2/R1)$

where R1 is the resistance between the OUT and ADJ terminals and R2 is the resistance between the ADJ terminal and ground (0V).

In this case, R1 = 100Ω and R2 = 300Ω, so $V_{OUT} = 1.25 \times (1 + 300/100) = 5V$

In practice, slight manufacturing variations mean that the 1.25 factor can be anywhere between 1.2 and 1.3. Because of this, the PC board has been designed so that there are three resistors in series between ADJ and GND terminals. This allows REG1's output to be fine-tuned by changing one or more resistor values, to obtain a supply rail that's very close to +5V.

Note, however, that this fine-tuning will not be necessary unless you plan to use the optional 10-way header (CON3) for in-circuit programming (and then only if the output voltage isn't close to +5V).

Zero-crossing detection

As well as driving the bridge rectifier, one side of the transformer's secondary winding is also fed to pin 17 of IC1 via 270Ω and 1kΩ resistors.

How The Software Works

The software is responsible for most of the Musicolour's functions and uses various interrupts to accomplish time-critical tasks.

For example, the multiplexed LED display is driven by the microcontroller using a periodic interrupt based on an internal timer. This allows the display refresh rate to be set by the software. Each time the timer expires, an interrupt occurs and display data is sent to the display driving hardware.

The display is 'multiplexed', meaning that only one column of seven LEDs is lit at any one time. The seven LEDs inside the tactile switches effectively form the 16th column of the display. The 'dead time' between screen refreshes can also be programmed, and this effectively controls the perceived brightness of the display.

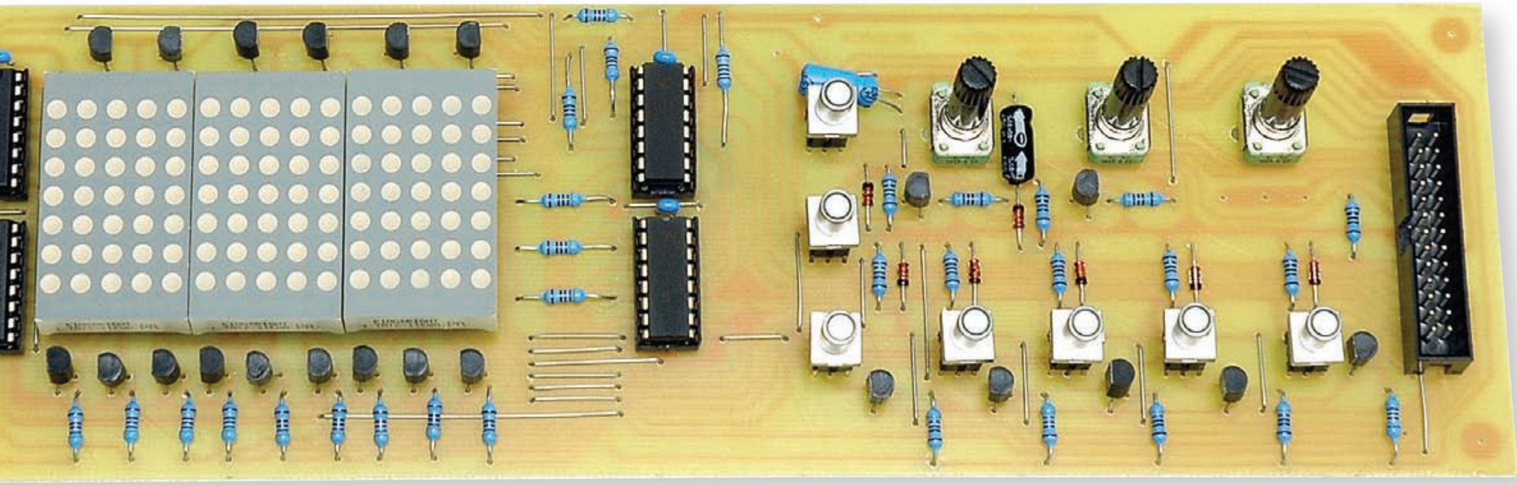
Pressing any of the seven tactile switches (S1-S7) also triggers an interrupt. The software then debounces the switch and adds the key press to an internal queue implemented as a FIFO (first in, first out). This ensures that there are no missed key presses due to software latencies.

The microcontroller is also responsible for digitising the four analogue input channels. Three of these are audio inputs coming from the op amp circuits, while the fourth is used to read the setting of potentiometer VR3. This latter value is used to change various settings, according to the menu selected.

Note that when changing a value with this potentiometer, the value will only begin to change when the potentiometer's setting matches the current value of the setting that's being changed. This gives the potentiometer a kind of 'memory'.

The analogue-to-digital conversion of the four input channels is automatically handled by the ADC subsystem within the microcontroller (IC1). Each channel is sampled at around 48kHz.

Most of the data produced is ignored and only one audio stream (or a mixed stream) is actually stored in an internal buffer. An interrupt is generated whenever the internal ADC system buffer (16 bytes)



These photos show the assembled Main Board and Display Board modules. The construction details are in next month's issue (note: boards are shown smaller than actual size).

Diodes D9 and D10 clip the positive and negative excursions of this AC signal to +5.6V and –0.6V respectively, to prevent damage to the microcontroller's INT0 input. In addition, the signal is bypassed using a 5.6nF capacitor to filter any noise on the line. This capacitor changes the phase of the signal slightly, but this effect is corrected by the software.

In operation, the microcontroller uses the clipped AC signal to detect the zero crossings of the mains waveform. This is necessary in order to correctly drive the triacs using phase control and to minimise the interference caused by the triacs switching the mains.

Basically, the INT0 (pin 17) input of the microcontroller functions as an edge-triggered external interrupt source. This is used by the software to phase control the four output channels.

That's all we have space for this month. Next month, we'll describe the assembly of the PC boards and the internal wiring.

Warning!

All the parts in the red shaded area on the Main Board circuit diagram (Fig.2) operate at mains potential (ie, 240VAC) and contact with any of these parts could be FATAL.

These parts include the PC tracks, the optocouplers (OPTO1-4), the triacs, the 100µH inductors, the 680Ω resistors, the 100nF 250VAC capacitors, screw terminal blocks CON4-CON6, the transformer primary and the wiring to the mains input and output sockets. DO NOT TOUCH any of these parts unless the power cord is unplugged from the mains supply. DO NOT CONNECT this device to the mains unless it is fully enclosed in the specified case.

This project is not for the inexperienced. Do not build it unless you know exactly what you are doing and are completely familiar with mains wiring practices and construction techniques.

is full. The firmware then stores only the relevant channel data in an internal buffer. This happens after any mixing, amplifying or averaging is performed on the audio data.

The FFT (fast Fourier transform) is computed in real time without loss of samples. This is accomplished by the software using double buffering.

While the FFT is being computed on the data stored in an internal buffer, another internal buffer is being filled by the interrupt servicing the ADC subsystem. When the FFT is finished on the active buffer, it is then computed on the other buffer. In this manner, the two buffers are alternately filled and then processed by the FFT.

Note that the microcontroller runs at close to 30MIPs using its internal clock source. This is fast enough to compute the FFT on the audio channels without loss of samples.

The frequency domain data output by the FFT is used to drive the triacs using phase control. For each output channel, an 8-bit brightness level is computed from the frequency domain data, depending on the settings for its frequency band.

An interrupt is used to detect the zero crossings of the mains waveform. When the zero crossing is detected, the microcontroller sets the triggering period for each of the four 'output compare' (OC1-OC4) channels. When each period expires, the microcontroller emits a short pulse at each output compare pin.

These OC pulses turn on their corresponding triacs until the next zero crossing of the mains waveform. The earlier in the half-cycle that each triac is triggered, the greater the power delivered to its load.

The effective power varies according to the area under the mains waveform from the trigger point in each half cycle. This relationship is not linear, and so an internal correction factor is calculated by the microcontroller to make the channel responses linear.

The microcontroller also adjusts the triggering periods of the output channels according to their quiescent current settings (ie, the user can set the 'off' level for each output channel). Most lamps will respond better with a small current flowing through them at all times, so that they glow faintly in the 'off' state. This will also increase lamp life.

Anyone On?

Mark Nelson

Liberalisation is supposed to be beneficial, but is deregulation of the airwaves leading to chaos in the home and office? A new technique called cognitive radio may just avoid this possibilty. Mark Nelson outlines both the problem and the palliative.

Although too much of a good thing can be simply marvellous, it doesn't always work out that way. Many resources need to be rationed for the common good. Imagine the mayhem that would ensue if the Government abolished car taxation and driving tests, allowing anyone who could afford a car to use it on the roads.

A nightmare scenario you might think, but in fact national administrations have done exactly this, not on the roads but with wireless connectivity. I'll return to this example of the law of unintended consequences after a short lesson from history.

Protocol for peace

Cast your mind back, if you can, to the party line. When the telephone service was run as a government corporation, funding for investment was always limited and right up to the 1980s some unfortunate people were forced to share a telephone line. Although the two subscribers sharing this 'party line' each had their own separate telephone number, one party could not make a phone call when the other was already using the line.

The same shortage of funds also affected the railways, where up to 20 or 30 signal cabins, booking offices and goods agents were obliged to share a single telephone line. Known as an omnibus circuit (omnibus meaning 'for everybody' in Latin), it used an elaborate system of code rings to call the intended location.

To avoid bad tempers on these shared party lines, a protocol was evolved for peaceful coexistence. It was a very practical arrangement; when you picked up the handset to make a call you simply asked: 'Anyone on?' in case you were interrupting a conversation that had gone quiet for an instant. Dial labels even carried the instruction 'Challenge line before calling' to reinforce the message.

Although party lines are few and far between these days (except on some preserved railways), the simplicity of this protocol served to avoid conflict and frayed tempers.

Radio gaga

Access to the airwaves has never been easier for the private citizen or businessman. It was only when Citizens Band radio and cordless telephones were finally legalised in the 1980s that 'Joe Public' was first allowed to transmit by radio without any kind of examination or licence. That was then, and these days your home and office are probably awash with wireless devices – WiFi radio LANs, cordless keyboards and printer connections, Bluetooth headphones, and goodness knows what else.

All this is totally legal and highly convenient for us users, but have you considered what happens when you install a new WiFi network in your flat? How do you know you have not just wiped out the wirefree speaker system on next door's audio system?

Don't tell me that it's their bad luck or that it cannot happen! There are loads of dodgy kits on the market that transmits out of band or above permitted power levels. And as Jean-Louis Evans for the British Approvals Board for Telecommunications states, 'The utopian idea that user dissatisfaction would identify non-compliant products simply won't work. Market forces alone cannot be relied upon to control this situation effectively.'

A new and equally potent catalyst for wireless disharmony is the femtocell. As we discussed just over a year ago, the femtocell is a user-owned and installed cellular base station for use in a domestic or small business setting. It connects to the service provider's network using your broadband connection to enable the local use of up to 16 mobile handsets.

These femtocells are particularly useful where mobile phone service is patchy or completely unavailable, but some people will inevitably use them where there's already radio coverage 'outdoors' and now the fun begins. If the femtocell is configured to transmit on a single default radio channel, you can imagine the mischief (read 'chaos') that this will cause. We're back to the mutual interference scenario from conflicting WiFi networks.

Thoughtful radio

What we need is a simple protocol in which these wireless devices ask, 'Is anyone already on this channel?' before blasting into the ether. You might term this thoughtful coexistence or plain common sense, but wireless engineers have a more technical name for it, 'cognitive radio technology'. What's more, they have devised the IEEE 802.22 standard to regulate use of the airwaves using this cognitive technique.

Cognition is the mental process involved in knowing, learning and understanding things, so cognitive radio is a technique for assessing the radio environment and making intelligent decisions on the bandwidth, form of modulation and power to be used. But a more practical explanation of how wireless works comes from radio amateur Ian Poole G3YWX, which is why I am taking the liberty of quoting some of his words of wisdom on the subject.

He states that a cognitive radio may be defined as a radio that is aware of its environment and its internal state. With a knowledge of these elements and any stored predefined objectives, it can make and implement decisions about its behaviour. This behaviour can include changing its transmission or reception parameters to communicate efficiently, avoiding interference with licensed or unlicensed users, based on active monitoring of factors such as radio frequency spectrum, user behaviour and network state.

Black box

Underlying this novel idea, which dates back to 1999, is the realisation that allocating rigidly defined chunks of the radio frequency spectrum to particular users will not make the most efficient use of the airwaves. At any given moment some frequencies will be in use and others will not. Radio users would get a better deal if we could design a fully reconfigurable wireless 'black box' that could change its communication variables automatically in response to network and user demands. Providing this level of reconfigurability calls for the use of software-defined radio or SDR. At the same time, achieving the full potential of the airwaves means that radio frequencies would have to be pooled to a much larger extent, without bands currently allocated to one single use such as television broadcasting, business radio, cellular radio or WiFi networking.

There's obviously a long way to go in optimising and implementing cognitive radio, but judging by the number of conferences on the subject and the interest shown by developers, academics and national (and international) regulatory organisations, it's clear that cognitive radio is becoming a topic of considerable importance.

The Plessey name is back

Nostalgic people may have had some regrets when the Plessey name, described by David Manners in trade paper *Electronics Weekly* as one of the most famous names in semiconductors, disappeared after the merger with GEC. The Plessey name lives on in South Africa, where a subsidiary company saw no reason to drop the decades-old name, and it reappeared in the UK when a British distributor brought in telephone systems from Africa.

Now the Plessey Semiconductors name – and the iconic 'scope trace emblem – have been revived at the original Plessey-built fabrication facility outside Swindon. The new company will offer its customers state-of-the-art semiconductors and you can read more at **www.plesseysemiconductors.com/about.html** .

PIC-Based Water Tank Level Meter

Part 2: By JOHN CLARKE

Building the two versions plus calibration and installation

Last month, we published the circuit of the Water Tank Level Meter and described how it worked. This month, we show you how to build both the basic and telemetry versions, as well as detailing the installation.

BOTH the basic and telemetry versions of the Water Tank Level Meter use the same PC board (code 753, 104mm × 79mm). This board is available from the *EPE PCB Service*. It is housed in a 115 × 90 × 55mm sealed polycarbonate enclosure with a clear lid.

The telemetry version uses a handful of extra parts, among them a 433MHz transmitter module and two BCD rotary switches. It also uses parts that are salvaged from a solar garden light. These include the solar cell, a single AA NiMH or NiCad cell, and the Schottky diode, which is used for diode D2.

This is by far the cheapest way to obtain the solar cell and you will also have some spare parts, such as a white LED driver, a white LED and garden light hardware components.

Typically, single solar garden lights cost around £5. Don't be tempted to get the multi-pack solar garden lights that sell for just a few pounds or less per light. These generally use lower quality solar cells.

Before removing the parts, it's a good idea to first charge the NiMH or NiCad cell by placing the garden light in the sun for a few hours. Don't forget to remove the insulation tab from the battery before doing this, otherwise it will never charge.

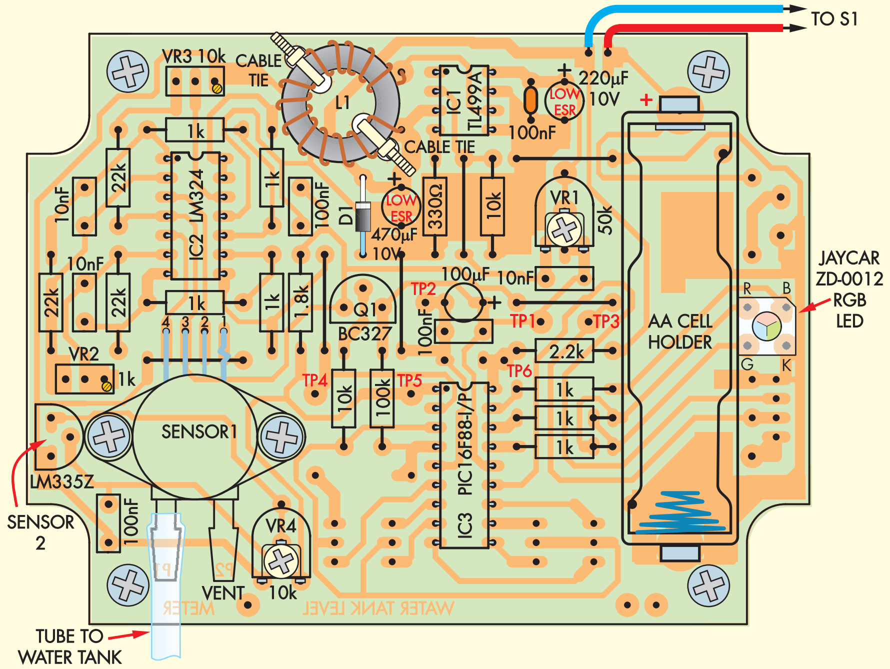


Fig.10 (below): this diagram shows the board layout if you use an RGB LED with a different pin-out to the Jaycar ZD-0012. Note the changes to two of the 1kΩ resistors.

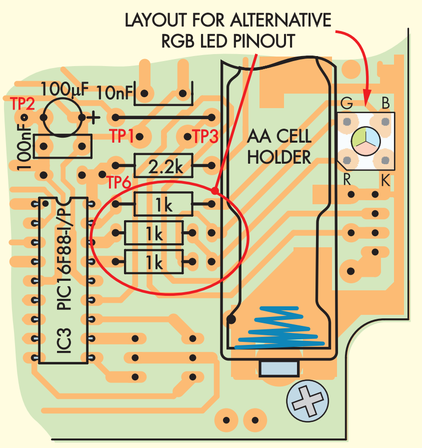


Fig.9: follow this parts layout diagram to build the basic version of the Water Level Meter. The pressure sensor is shown mounted on the board here, but we now recommend installing it in a separate box that either sits on the bottom of the tank or is attached to the side of the tank.

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	100kΩ	brown black yellow brown	brown black black orange brown
❏	3	22kΩ	red red orange brown	red red black red brown
❏	2	10kΩ	brown black orange brown	brown black black red brown
❏	1	2.2kΩ	red red red brown	red red black brown brown
❏	1	1.8kΩ	brown grey red brown	brown grey black brown brown
❏	7	1kΩ	brown black red brown	brown black black brown brown
❏	1	330Ω	orange orange brown brown	orange orange black black brown

Once that's done, you can remove the solar cell, the rechargeable AA cell and the 1N5819 Schottky diode (or equivalent).

Software

The software files are available via the EPE Library site, accessed via **www.epemag.com**. Pre-programmed PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

Board assembly

Begin construction by checking the PC board for any defects such as shorted tracks or breaks in the tracks. It's rare to find such defects these days, but it's always a good idea to make sure as it's easier to spot any defects before the parts are installed.

Check also that the hole sizes are correct. The four corner mounting holes should all be 3mm in diameter, as should the mounting holes for Sensor 1 and the holes for the cable ties that are used to secure inductor L1. That done, check that the PC board is cut and shaped to size so that it fits into the box.

Fig.9 shows the parts layout diagram for the basic version, while Fig.11 shows the PC layout for the telemetry version. Just follow the diagram for the version you are building.

Note that if you build the basic version, this can later be upgraded to the telemetry version simply by adding the extra parts. The software for the PIC micro is the same for both versions.

Begin the board assembly by installing the six wire links, then install the resistors. Table 1 shows the resistor colour codes, but you should also use a DMM (digital multimeter) to check each resistor because the colours can sometimes be difficult to decipher.

Note that if you are using the Jaycar RGB LED, then the 1kΩ resistors immediately to the left of the cell holder are installed as shown in Fig.9 and Fig. 11. However, if you are using a

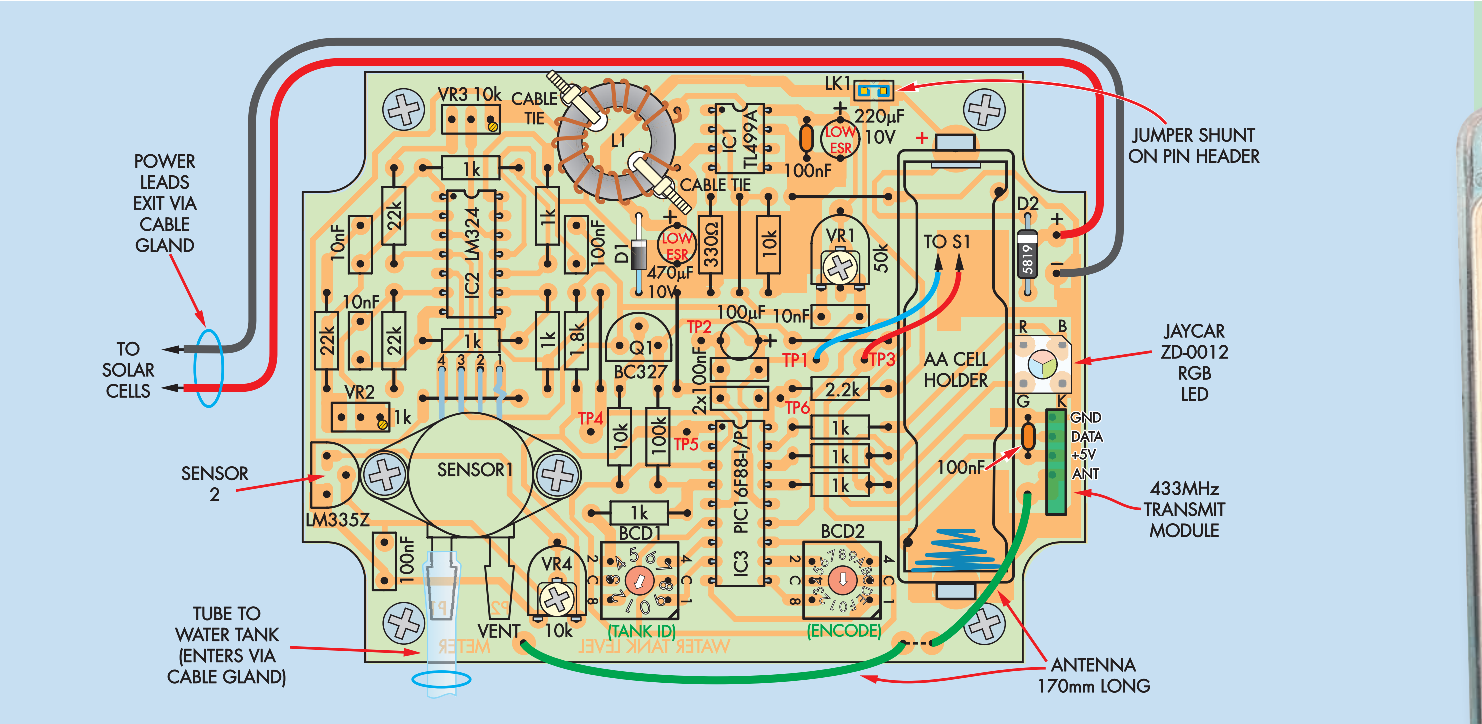
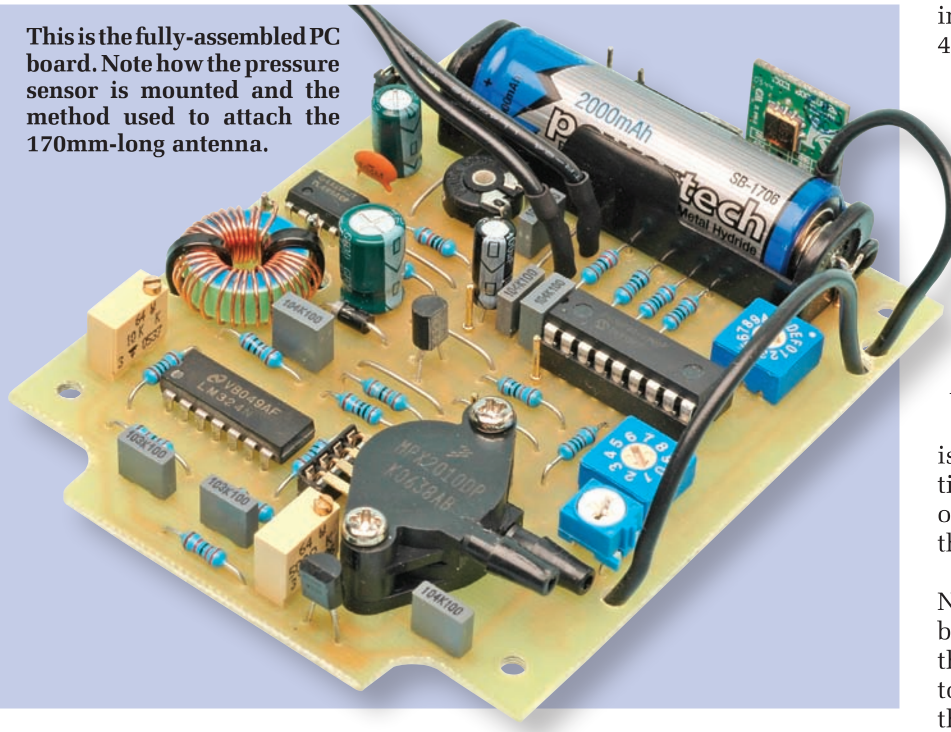


Fig.11: this is the parts layout for the telemetry version of the Water Level Meter. It basically adds the 433MHz transmitter module, two BCD switches, diode D2, jumper shunt LK1, a 1kΩ resistor and two 100nF capacitors.



This is the fully-assembled PC board. Note how the pressure sensor is mounted and the method used to attach the 170mm-long antenna.

different RGB LED that has the alternative pinout, the resistors must be connected as shown in Fig.10.

Next, install PC stakes at test points TP1 to TP6, at either end of the cell holder position and at the termination points for inductor L1. That done, install a couple of PC stakes at top right to terminate the leads for switch S1 (basic version only). Alternatively, fit a 2-way pin header to these PC stakes if you are building the telemetry version (see Fig.11).

If you are building the telemetry version, install an additional PC stake to terminate the antenna lead – this goes in immediately to the bottom left of the 433MHz transmitter module.

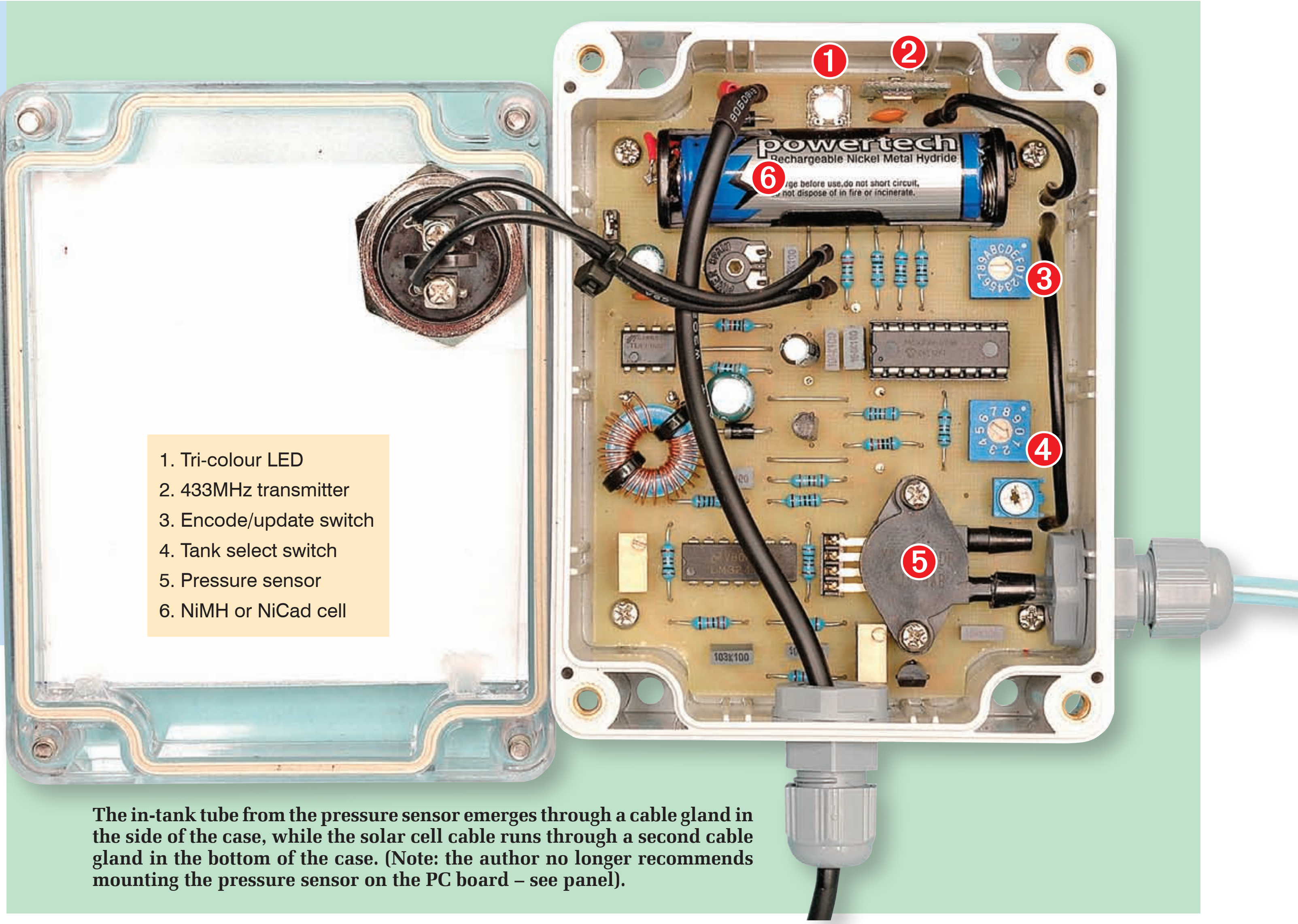
Follow these parts with diode D1 (and D2 for the telemetry version), then install the ICs. IC1 and IC2 can be directly soldered to the PC board, while IC3 (the PIC micro) should be installed using a socket. Take care with the orientation of each IC and the socket.

Don't plug IC3 into its socket yet – that step comes later, after the power supply has been checked.

A 4-way single-in-line (SIL) socket is used for the pressure sensor connection. This can be made by cutting off one side of an 8-pin IC socket to obtain the 4-way socket strip.

The capacitors are next on the list. Note that the electrolytic types must be oriented as shown. Note also that there are two types of 100nF capacitors: the rectangular MKT types and the ceramic disc-shaped types. Be sure to install the 100nF ceramic capacitor(s) in the positions shown.

Follow these with transistor Q1, the LM335Z temperature sensor (Sensor 2) and trimpots VR1 to VR4. Note that it's a good idea to orient the multiturn trimpots as shown (ie, screw adjustments to the right) so that the sensor signal from IC2c increases as the



The in-tank tube from the pressure sensor emerges through a cable gland in the side of the case, while the solar cell cable runs through a second cable gland in the bottom of the case. (Note: the author no longer recommends mounting the pressure sensor on the PC board – see panel).

adjustment wipers (moving contacts) are turned clockwise.

Be sure to use the correct value trimpot in each position. Trimpots are usually marked with a code instead of the actual value. This means that the 50kΩ trimpot (VR1) may have a '503' marking, the 10kΩ trimpots (VR3 and VR4) may be marked as '103' and the 1kΩ trimpot may be marked as '102'.

Installing Sensor 1

Sensor 1 can either be installed directly on the PC board (no longer recommended – see footnote panel) or it can be mounted in a separate box and submerged in the water tank (see Fig.14). In the latter case, it's connected back to the PC board via a 4-way cable.

If you elect to install it on the PC board, you first have to bend the leads down through 90° so that they can be inserted into the 4-way SIL socket strip. However, take care to orient the sensor correctly. It must be installed with its notched pin to the right and with the type markings for the sensor (MPX2010DP) visible on top.

Once the sensor is in position, it can be secured in place using two M3 × 15 screws and nuts.

The AA cell holder can be installed now. It's secured to the PC board using two No.4 self-tapping screws. That done, wire the cell holder's leads to the adjacent PC stakes.

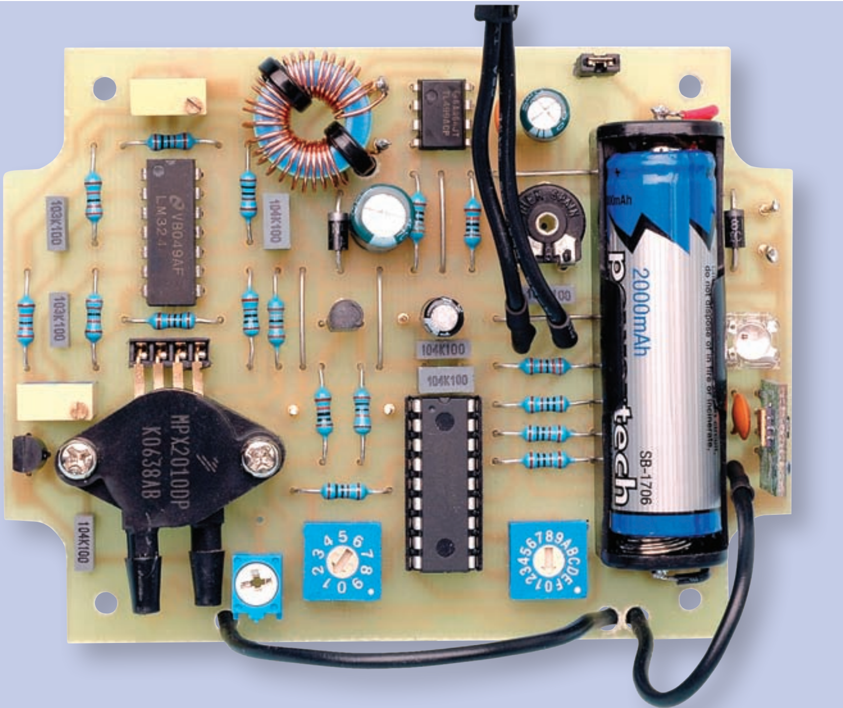
Telemetry version parts

If you are building the telemetry version, the next step is to install the BCD switches. Note that these have an orientation dot that must be positioned as shown. In addition, be sure to install the 0-9 position switch in the BCD1 position and the 0-F switch in the BCD2 position (see photos).

Once these parts are in, install the 433MHz transmitter module (it goes in just below the RGB LED). Make sure this part is correctly oriented – the pin designations are labelled on both the transmitter PC board and the main board, so be sure to match them up.

The antenna is made using a 170mm length of hookup wire, which is soldered to the antenna PC stake (immediately to the left of the transmitter module). As shown, it's then fed through three holes in the PC board to hold it in position.

Alternatively, for long-range transmissions over 50m, the antenna should be made using a 170mm-long length of 1mm enamelled copper wire. This wire is stripped of insulation at one



Here's another view of the assembled PC board. Don't get the BCD switches mixed up and be sure to orient them correctly.

end and soldered to the antenna PC stake. It then protrudes through a small hole in the side of the box.

Finishing up

Inductor L1 is made by winding 27 turns of 0.5mm enamelled copper wire onto an iron-powder toroid core. Wind the turns on evenly around the toroid, then scrape away the enamel at the wire ends using a sharp hobby knife and tin them with solder.

Inductor L1 should now be secured in place using two cable ties, as shown in the layout diagrams. Once it's in position, solder its leads to the adjacent PC stakes.

Next, for the basic version, connect switch S1 to the 2-pin header. Alternatively, for the telemetry version, install a jumper shunt over the 2-pin header and connect switch S1 between TP1 and TP3 (see Fig.11).

Testing

To test the unit, first insert a charged NiMH (or NiCad) or alkaline cell into the holder and connect a multimeter between test points TP1 and TP2. That done, set the multimeter to read volts and press switch S1 if you built the basic version (pressing S1 is not necessary for the telemetry version).

Now adjust trimpot VR1 for a reading of 5.0V. When that's correct, check that 5V is also present between pins 14 and 5 of IC3's socket.

You now need to follow this step-by-step set-up procedure:

1) Switch off and insert IC3 into its socket (make sure it's oriented correctly).
2) Connect a multimeter between test points TP2 and TP4.
3) If you have the basic version, connect a link between TP1 and TP3. Switch on, press S1 and adjust trimpot VR3 for a reading of 1.0V on the multimeter.
4) Connect the multimeter between TP2 and TP5 and adjust trimpot VR4 for a reading of 2.98V when the ambient temperature is 25°C degrees. You can also make this adjustment at any ambient temperature by setting VR4 so the reading is 2.73V plus the temperature, divided by 100.

   For example, if the ambient temperature is 15°C, the voltage should be adjusted to 2.73V plus 0.15V, ie 2.88V. Table 2 provides all the values, to save you doing the calculations yourself.
5) Remove the cell and disconnect the short between TP1 and TP3 for the basic version.
6) Reinsert the cell.
7) Check that the RGB LED now lights for two seconds when switch S1 is pressed with either version. If this does not happen, check that the RGB LED is oriented correctly.

Final assembly

If you buy a kit for this unit, then the box will be supplied with all the holes drilled. If not, you will have to drill the holes yourself. Fig.12 shows the drilling details.

Note that some of the internal ribbing will have to be removed where the nut for the pressure sensor cable gland is located, so it can sit flat against the side of the box. You can use a sharp chisel or a file to remove these. For the telemetry version, an extra cable gland is required for the solar cell lead, and this can be mounted on the end of the box.

A small hole must also be drilled in the box to allow the air pressure inside to vary in line with the atmospheric pressure (this air pressure is applied to the P2 port of the pressure sensor). The exact hole position will depend on your particular installation. It must be located on the lowest face of the box, so that rainwater cannot enter it. A hole with a diameter of just 1.5mm is required.

Finally, a diffuser should be attached to the inside top of the lid above the RGB LED. This makes the colours more obvious by blending the individual red, green and blue spots of colour from the RGB LED.

A suitable diffuser can be made using a translucent strip cut from a plastic A4 folder. This can be affixed inside the lid using clear silicone sealant. Alternatively, you can diffuse the inside area of the lid just above the LED by using some fine-grade sandpaper to roughen up the transparent surface, thereby making it translucent.

Installation

The Water Tank Level Meter can either be attached directly to the tank or mounted on a nearby wall. Whichever method you choose, it must be mounted so that it is always out of the direct sun. This is necessary to prevent the temperature sensor reading excessively high and producing incorrect temperature compensation.

The positioning also depends on your tank and whether you have built the basic or the telemetry version. For the telemetry version, the unit also needs be positioned so that the base

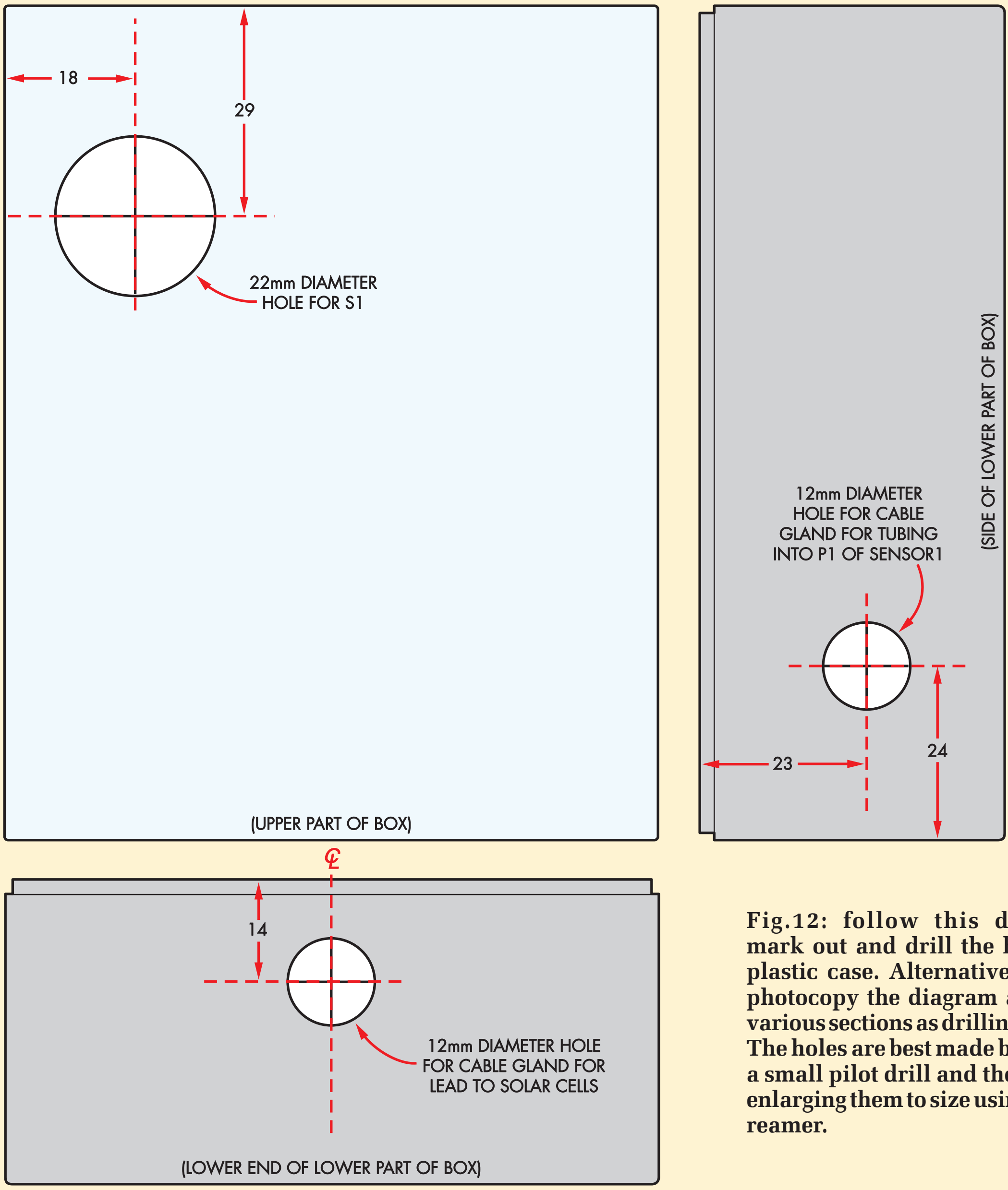


Fig.12: follow this diagram to mark out and drill the holes in the plastic case. Alternatively, you can photocopy the diagram and use the various sections as drilling templates. The holes are best made by first using a small pilot drill and then carefully enlarging them to size using a tapered reamer.

station can receive the transmitted signal. In this case, we suggest you build the Base Station to be described next month before deciding on a mounting position for the meter.

Note that the specified box has four mounting points that are effectively outside the box's sealed section, but which are covered by the lid. It's simply a matter of removing the lid to access these mounting holes.

By the way, do not drill holes anywhere in a concrete tank, as this can cause cracks that can leak. By contrast, plastic and steel tanks can have mounting holes drilled in the top cover, *but not the sides*. Plastic tanks also usually have lifting points, and you can either drill into these sections or use the existing lifting hole for mounting.

If you want to mount the box on the side of the tank, the best approach is to first secure two 19mm × 19mm × 120mm hardwood batons to the tank using builders' adhesive or silicone sealant. These should be spaced to match the box's mounting holes. The box can then be attached using short wood screws into the timber (make sure that these screws are short, so that they cannot possibly go all the way through the timber and puncture the tank).

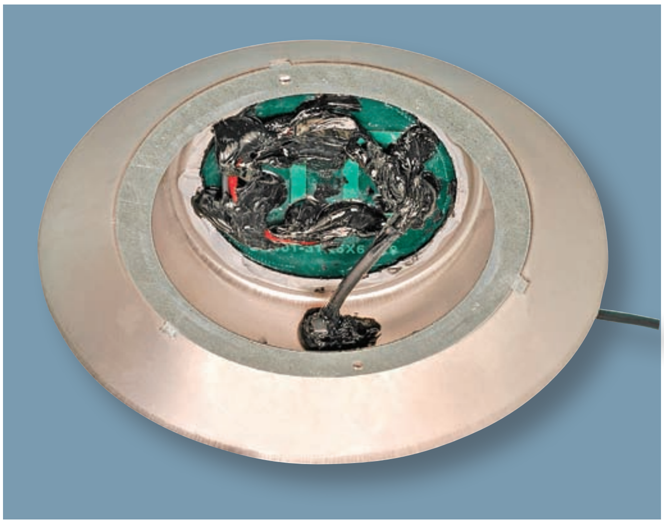
Solar cell mounting

In most cases, you can use the stainless steel surround supplied with the solar-powered garden light as its mounting bracket. A convenient mounting location is on top of the water tank itself, provided it receives adequate sunlight.

Alternatively, you can mount the solar cell on the house (or shed) roof, or even install it on the ground using the garden light fittings. Note that it should face south towards the midday sun, to ensure best performance.

In practice, this means tilting the cell away from the horizontal (in a southerly direction) by about your

The solar cell was salvaged from a defunct garden light. It can be left in its original aluminium housing to facilitate mounting.



The connections to the solar cell are coated with neutral-cure silicone sealant to make them waterproof and to anchor the leads in position (see text).

latitude plus 15°. You may well need to experiment to get an optimal angle.

The lead between the solar cell and the Water Level Meter should be run using single-core microphone cable. In most cases, you will have to drill a hole in the stainless steel housing to feed this lead through to the cell. A rubber grommet should then be fitted to this entry hole to prevent damage to the cable.

Use the core wire for the positive connection to the cell, and the shield for the negative connection, but note that the connections to the solar cell are easily damaged, so take care here. In practice, it's best to use neutral-cure silicone sealant to first secure the leads that are already attached to the cell. The microphone cable is then soldered directly to these leads, and the connections anchored and waterproofed using additional silicone.

Finally, the microphone cable itself can be secured using silicone, especially around the entry grommet. A plastic cable tie can also be fitted to the cable, to prevent it from being pulled back through the grommet.

At the other end, the microphone cable passes through the cable gland in the box, and its leads soldered to the solar cell PC stakes.

Installing the tubing

In most cases, the plastic tubing that goes into the tank can be inserted through a small hole in the inlet screen – especially if it isn't exposed to the sun. If it is exposed, we recommend shielding the tubing with some white flexible conduit to prevent excessive solar heating.

Alternatively, with a steel or plastic tank, the tube can be inserted through a hole drilled in the top of the tank, in a position that's shaded from the sun.

Before installation, you will first have to remove the insect screen or manhole to gain access to the inside of the tank. If the tank isn't full, measure the distance from the full position down to the current level and record this for later use.

To support the pressure sensor tubing, a length of 25mm PVC tubing wedged between the base and the roof of the tank can be used – see Fig.13. The top of this pipe can later be secured to the roof of the tank using silicone sealant or builders' adhesive (ie, after calibration). As shown, the 3mm sensor tubing is attached to the 25mm PVC tubing using cable ties.

Alternatively, a weight could be attached to the end of the tubing to hold it down, but don't use anything that will contaminate the water, such as lead. This weight needs to be about 150g per metre of tubing in the water. A 2.54cm (or larger) galvanised steel water-pipe end-stop is recommended.

The best way to attach this weight is to first drill a 6mm hole through the top, so that the tube can protrude a little way inside the end stop. This hole should be large enough to let water pass around the outside of the tube. The tube is then secured to the weight using cable ties on either side of the hole.

Whichever method you use, the assembly should be adjusted so that when it is later placed inside the tank, the end of the 3mm tube is level with the bottom of the tank's outlet pipe.

Note that if the access hole in the top of the tank is some distance away from the screened inlet, it may be necessary to pull the 3mm tubing through using a draw wire. Similarly, if you need to remove the assembly, then you may have to retrieve it using a pole with a hook.

As stated previously, it's important to route the tubing between the tank and the Level Meter so that it is not exposed to direct sunlight. If necessary, it can be protected from the sun by covering it in flexible PVC tubing.

At the Level Meter, the tubing runs through the cable gland in the side of the box and fits over the Port 1 nozzle of the pressure sensor. In most cases, you will have to gently heat the end of the tube using a hot-air gun so that it will slide over the nozzle.

This should form an airtight connection, but if you have any doubts, apply some silicone sealant around the connection behind the nozzle flange. Clamping the tube with a cable tie can also help prevent air leaks.

The rest of the tubing and its weight can now be lowered into the water tank until it sits in the correct position. That done, wait for at least an hour for the air temperature inside the tube to stabilise. This is necessary because the cooling effect of the tank water can affect calibration.

At the end of this one-hour period, remove the tube from the tank, shake

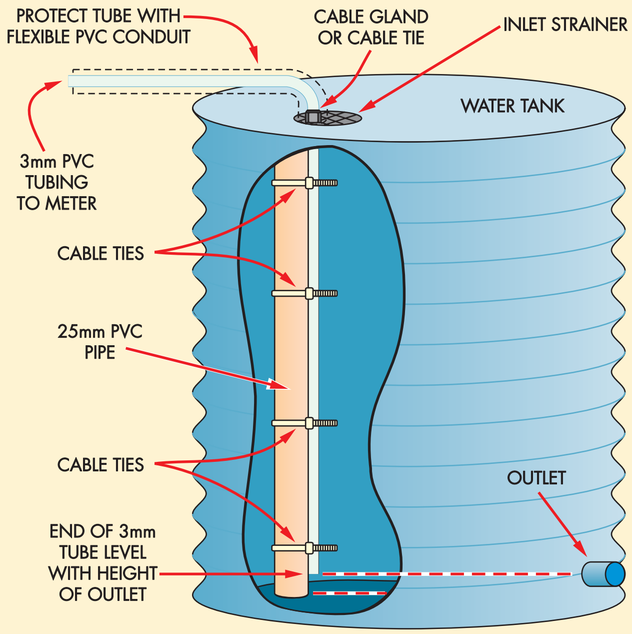


Fig.13: the 3mm PVC tubing that runs to the pressure sensor is installed as shown here. The 25mm PVC pipe is used to keep this tubing vertical in the tank. Note that the end of the 3mm tube should sit level with the base of the tank's outlet. (NB this method is no longer preferred by the author).

it so that all water runs out, then re-install it in the tank. Complete the installation by replacing the inlet screen filter or manhole cover on the tank.

Note that it is always necessary to lower the tube assembly into the tank after connecting it to the pressure sensor. If this is not done, the water will not pressurise the air inside the tube.

Calibration

Setting up is simply a matter of calibrating the Level Meter to the current water level in the tank. If the tank is full, then the meter is calibrated to read 100%. Similarly, if it's half-full, the meter is set to read 50%. Note, however, that to ensure accuracy, it's best to calibrate the meter when the tank is at least 25% full.

The step-by-step calibration procedure is as follows:

1) Determine the water height that represents 100% full. This is done by measuring the vertical distance between the outlet hole at the bottom of the tank and the overflow pipe at the top. If there's no overflow pipe, then measure to the bottom of the inlet strainer.
2) Measure the actual depth of the water (ie, the distance between the top of the water and the outlet pipe). You can easily calculate this depth by measuring the distance to the top of the water and then subtracting this from the full water height.
3) Calculate the water level in the tank as a ratio of full capacity. This means dividing the actual water height by the full water height.
4) Use this ratio to calculate the calibration voltage. This is done by first multiplying the ratio value by 2 (this converts it to the 2V range that the meter uses for water level measurement) and then adding 1 (since the calibration voltage is 1V when the tank is empty).

For example, if the tank is half full, the full-height ratio is 0.5. This value is then doubled (0.5 × 2 = 1) and then 1 is added to give a result of 2V. Similarly, if the tank is two thirds full, the result is (0.66 × 2) + 1 = 2.32V. And if the tank is full, the result (1 × 2) + 1 = 3V.

(5) Calibrate the meter by adjusting trimpot VR2 to set the voltage at TP4 to the calculated calibration value. Note that switch S1 will have to be pressed while you do this.

Note also that for the basic version, power will only be applied to the sensor while the tri-colour LED is alight. This means that if the LED goes out and you need more time to adjust VR2, the switch will have to be pressed again.

6) If practical, remove the tubing from the tank again and shake the water out. Adjust trimpot VR3 (offset) for a reading of 1V between TP4 and TP2.
7) Reinstall the tube assembly in the tank and readjust VR2 to give the calibration voltage at TP4 (ie, between TP4 and TP2).

Table 2: TP5 voltage vs temperature

Temperature (°C)	TP5 Voltage
10	2.83
11	2.84
12	2.85
13	2.86
14	2.87
15	2.88
16	2.89
17	2.90
18	2.91
19	2.92
20	2.93
21	2.94
22	2.95
23	2.96
24	2.97
25	2.98
26	2.99
27	3.00
28	3.01
29	3.02
30	3.03
31	3.04
32	3.05
33	3.06
34	3.07
35	3.08
36	3.09
37	3.10
38	3.11
39	3.12
40	3.13

Calibration temperature

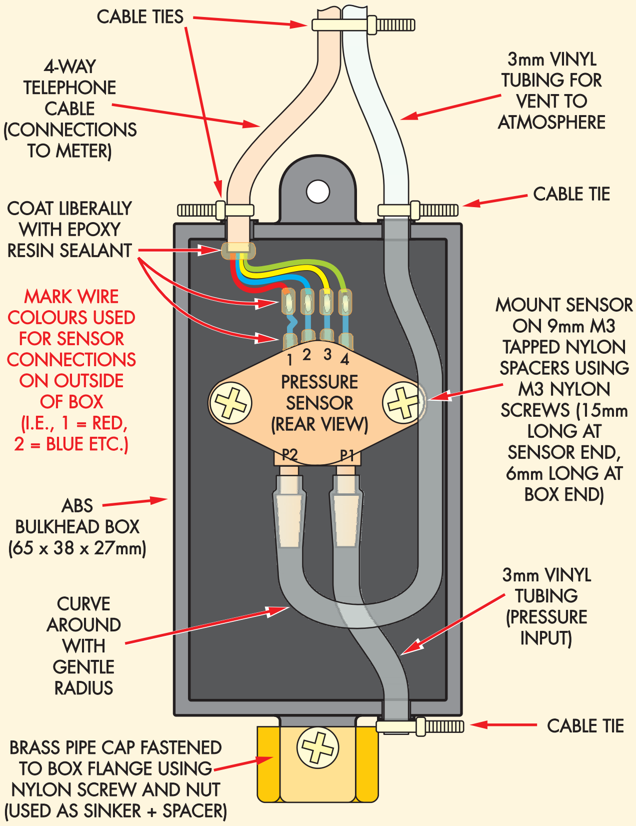
The next step involves setting the current calibration temperature, so that the readings can be corrected for any subsequent temperature changes. Note, however, that if you intend mounting the pressure sensor inside the tank, this procedure is not required.

Setting the calibration temperature is easy – simply connect a short jumper lead between test points TP2 and TP6. For the telemetry version, the RGB LED should immediately flash green three times. If it doesn't, try removing the jumper at LK1, then wait a few seconds and reconnect the jumper again. For the basic version, S1 must be pressed for the LED to flash when the jumper is connected.

Note that if the tank ever runs dry, then the air trapped in the tube when the water subsequently rises again may

continued on page 32

Building The In-Tank Pressure Sensor



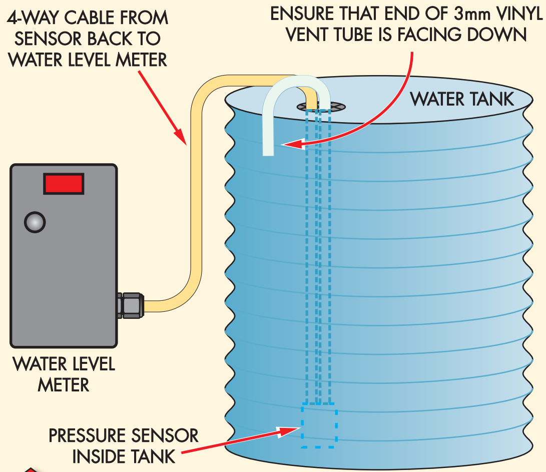


Fig.15: here's how the in-tank pressure sensor is installed and connected to the Water Level Meter. The end of the tube connected to port P1 should sit level with the bottom of the tank's outlet pipe.

Fig.14: follow this diagram to build the in-tank pressure sensor. Make sure that all electrical connections are sealed with epoxy resin and that the box is filled with silicone sealant, as described in the text.

INSTEAD OF mounting the pressure sensor on the PC board, the author now recommends that it be mounted in a separate small box, which is then placed at the bottom of the tank. The sensor's leads are then connected back to the PC board via a 4-wire telephone cable fitted with a 4-way header plug.

The big advantage of this scheme is that the sensor now directly measures the water pressure. This eliminates the problems associated with air-pressure variations within the connecting tube due to temperature.

In practice, a short air-tube is fitted to prevent direct water contact to the sensor's element, but this has little effect on the readings. That's because this tube is very short (just 40mm long) and because of the much more stable temperatures inside the water tank.

Fig.14 shows the assembly details for the 'bottom of the tank' sensor. As shown, the sensor is mounted on two M3 x 9mm tapped nylon spacers, and has a 'snorkel' attached to its P2 port which vents to the atmosphere.

The short tube attached to P1 port just exits from the bottom of the box. As stated, the air inside this tube isolates the water from the sensor. This air will remain in the tube unless the assembly is inverted in the water tank.

The snorkel tube has to be long enough to reach beyond the top of the tank. It can exit either via a hole in the insect screen or the tank's lid, and must be positioned to keep out both rainwater and any run-off from the tank itself.

In practice, this means that the tube must be bent so that the end faces downwards after it exits from the tank – see Fig.15. This can be done by gluing the tube down the side of the tank (eg, using silicone). Make sure that the radius of the bend is large enough to prevent the tube from kinking.

When installing the wiring, be sure to make a note of the wire colour used for each sensor connection. This will make it easy when it comes to making the connections to the 4-way pin header that plugs into the sensor's socket on the Water Level Meter's PC board.

By the way, the pressure sensor in Fig.14 is depicted from the rear, whereas Fig.9 and Fig.11 show the sensor from the front. As a result, the pin designations run in different directions. Be sure you match up the pins correctly.

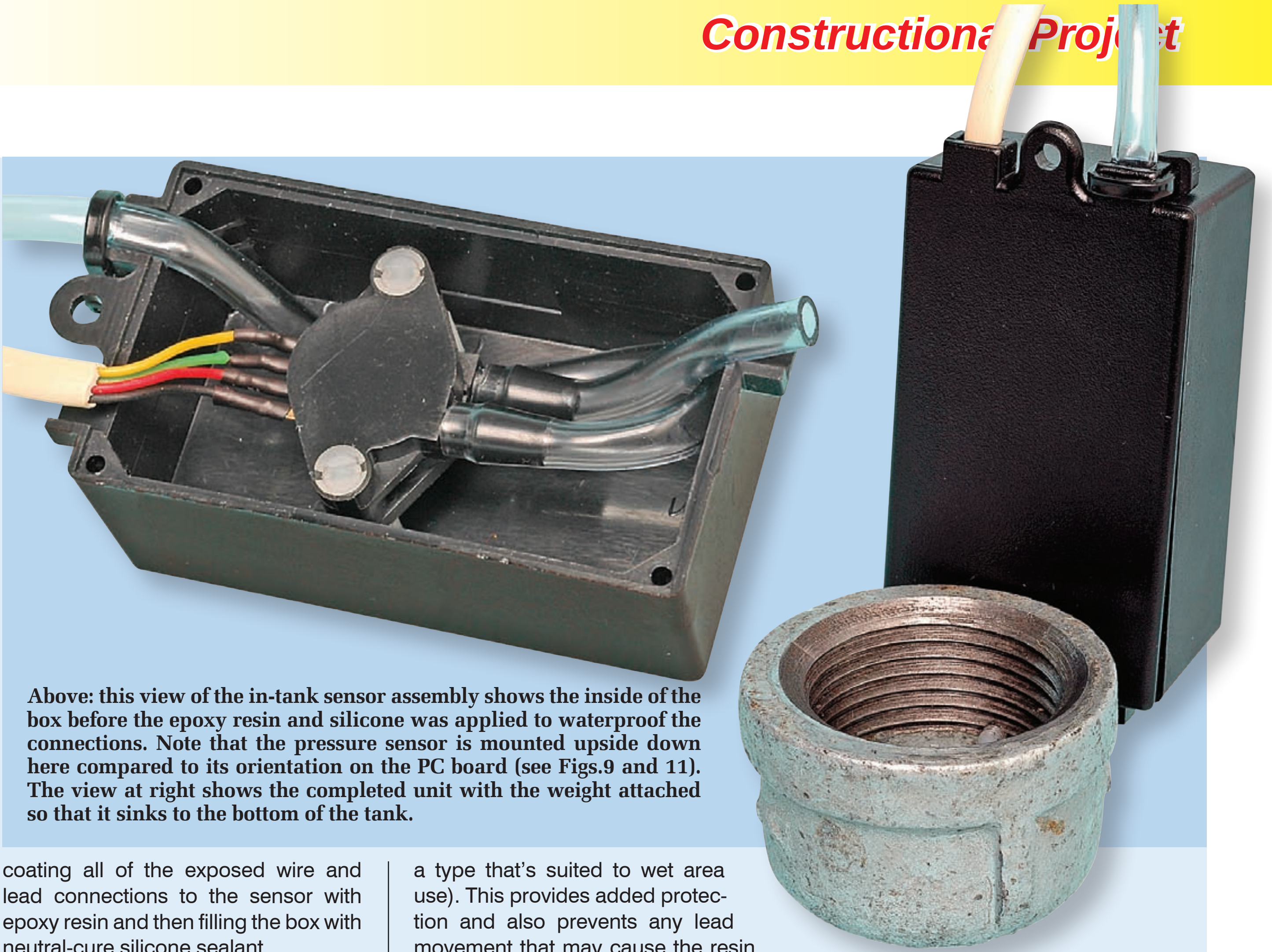
Fortunately, if you do get the connections to the sensor reversed, it is unlikely to be damaged. That's because the sensor comprises piezo resistive elements that act just like resistors. However, it will not operate unless it is connected correctly.

Note that the 4-way header that plugs into the PC board will not fit through the cable gland. This means that the lead must be passed through the gland first, before making the final connection to the 4-way header.

The next step is to check that the unit is operating correctly by blowing gently into the short tube (ie, the one going to port P1). The RGB LED should immediately light up to a colour higher than red (depending on the pressure) when the LED display is activated (eg, by pressing switch S1).

If it doesn't, check the wiring connections and check that the sensor port connections are correct.

If it works OK, then the connections are ready to be sealed. This involves



Above: this view of the in-tank sensor assembly shows the inside of the box before the epoxy resin and silicone was applied to waterproof the connections. Note that the pressure sensor is mounted upside down here compared to its orientation on the PC board (see Figs.9 and 11). The view at right shows the completed unit with the weight attached so that it sinks to the bottom of the tank.

coating all of the exposed wire and lead connections to the sensor with epoxy resin and then filling the box with neutral-cure silicone sealant.

Note that the epoxy resin used must be suitable for use in wet conditions and must adhere to both PVC and thermosetting plastics; eg, J-B Weld (part No.8270) and Bostik Titan Bond Plus. It should be mixed according to the instructions and applied to totally cover the attachment points where each sensor lead enters the sensor body.

In addition, you should apply resin around the central seal between the two halves of the sensor. Note that you will need to temporarily remove the sensor from the box in order to access the whole underside section.

Next, use epoxy resin to cover the whole length of the lead connections up to where they enter the outer sheath and around the end of the sheath itself. You should also lightly coat the gland in the box where the cable exits, so that the cable will be affixed in position.

That done, remount the sensor and clamp the 4-way cable in place on its gland until the resin cures. Once it has cured, check the coating for any gaps and recoat if necessary.

Filling the case with silicone

The inside of the box must now be filled with neutral-cure silicone (use a type that's suited to wet area use). This provides added protection and also prevents any lead movement that may cause the resin to crack.

First, apply the silicone so that it reaches to the top of the box, but do not overfill. That done, allow the silicone to cure without the lid in place. During this period, the tubing should be held in place at the exit points using cable ties or bulldog clips.

Be sure not to let any silicone get inside the short tube connected to port P1 during the above procedure.

It will take some 24-72 hours for the silicone to cure, depending on the type used. Once it has cured, apply additional silicone all around the edges of the box so that the lid can be sealed.

Note that the specified box has two outlet slots at one end and one outlet slot at the other, with matching flanges on the lid. Each slot can be held closed with a cable tie around the exposed flanges. These cable ties will crimp the tubes a little but not enough to close them.

Weighing it down

A weight must be attached to the bottom of the box so that it sinks to the bottom of the tank.

As shown in Fig.14, you can use a 25mm ID brass pipe end-cap for this weight (or you can use galvanised steel). This can be secured to a mounting eyelet at the end of the specified box using a nylon screw and nut.

Alternatively, the box can be attached to a length of 25mm PVC conduit tube, as before.

No temperature compensation

Another advantage of the in-tank sensor installation is that temperature compensation is not required (although temperature calibration is still carried out). This means that if the compensation has already been set (eg, if you are converting to the in-tank sensor set-up), then it will need to be adjusted to the no compensation setting (see main text).

Finally, the calibration procedure is the same as for the in-tube method – ie, the sensor is inserted into the tank and trimpot VR2 adjusted to set the calculated calibration voltage on TP4 (see main text). That done, the sensor is removed from the tank and VR3 is adjusted for a 1V reading at TP4. The sensor is then reinstalled and VR2 again adjusted to set the calibration voltage at TP4.

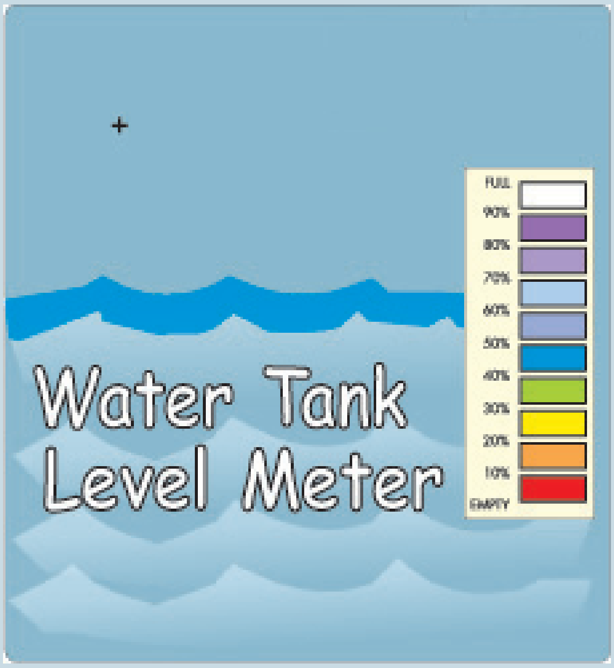


Fig.15: this full-size front panel artwork can be cut out and used directly.

be at a different temperature to that set during the calibration. As a result, the calibration may be slightly in error.

Generally, this will not cause much of a variation in level readings. However, if you are using temperature compensation, you can correct the reading by momentarily linking TP6 to TP2 to set a new calibration temperature.

If running out of water is going to be a constant problem, you can install the pressure sensor inside the tank instead – see panel.

Temperature compensation

Having set the calibration temperature, check the water tank level readings over a wide temperature range during the day. You probably will not notice any variations with the basic version because the graduations are in 10% steps, and so there is no need

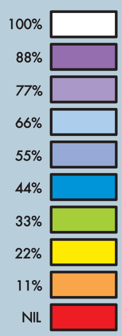


Fig.16: this chart shows the LED colours produced for the temperature compensation adjustment.

to apply temperature compensation. Conversely, when using the unit with the Base Station (to be described), any small variations will be seen, and so compensation is worthwhile.

Basically, if the reading rises with higher ambient temperatures and falls with cooler temperatures, then temperature compensation can be applied to improve accuracy. Initially, no compensation is set, but you can alter the compensation in 10 discrete steps.

The amount of compensation required will depend on the length of tubing exposed to the air outside the tank compared to the length inside the tank. To some extent, it also depends on the pressure sensor and its variation in output with temperature. This can be up to a 4% change over 85°C.

Changing the compensation

To change the temperature compensation value, you first need to connect a link between TP5 and TP2. If you have the basic version, you then simply press switch S1 to change the compensation.

Similarly, for the telemetry version, you have to remove jumper LK1, wait for a few seconds and then reattach the jumper (to apply power).

Each time you do this, the compensation will step to the next value and the LED display will light to indicate this. The indicated compensation level follows the same colour pattern as for water level, with red indicating zero temperature compensation and white indicating full compensation – see Fig.16.

Note that to reduce the compensation from the current setting, you will have to cycle through the colours to return to the wanted colour.

You will need to experiment to arrive at the best compensation setting. As a guide, full compensation gives a variation of about 10% for a 30°C range in temperature. Don't forget to remove the link between TP5 and TP2 after you are finished.

Low battery voltage

Finally, note that the solar cell will not recharge an NiMH (or NiCad) cell if the cell voltage drops below about 1.0V. That's because the step-up voltage converter circuit (based on IC1) draws excessive current from the rechargeable cell in an attempt to maintain a 5V output, but the solar cell cannot match this current.

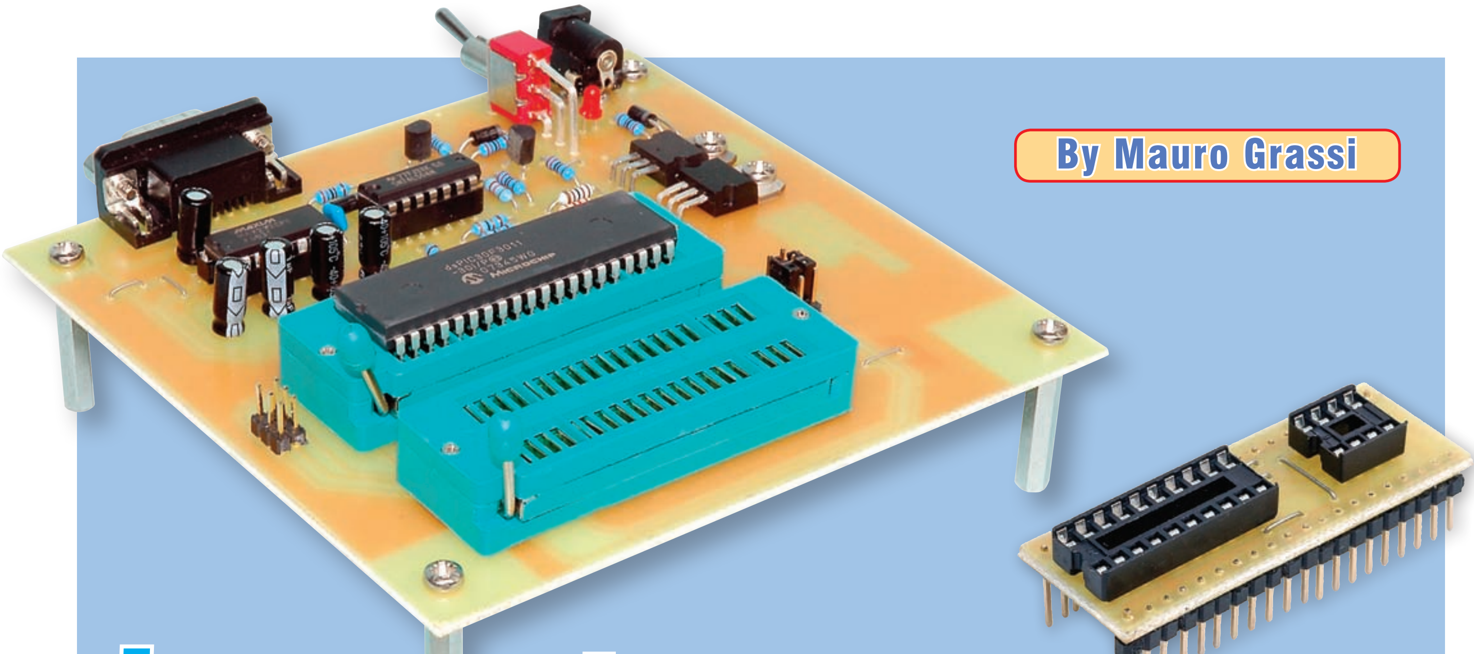
In that case, you can recharge the cell by removing jumper LK1, so that the cell is disconnected from the circuit while it charges.

That's all for now. Next month, we'll describe the LCD Base Station and an improved pressure sensor that doesn't require tubing inside the tank or temperature compensation. ***EPE***

Building an improved pressure sensor

ALTHOUGH THE PC board was originally designed to accept the pressure sensor, the author no longer recommends mounting this sensor on the PC board and prefers using the 'tube in tank' method of Fig.13 for water level sensing. That's because the measurement will become inaccurate after an extended period of time due to some diffusion of the air into the water, resulting in loss of pressure.

Therefore, the author now recommends that the pressure sensor be mounted inside the tank – see Fig.14. An even better scheme is to mount the sensor in a separate box outside the tank, with its input connected directly to the outlet at the base of the tank via a T-piece. This 'improved' sensor is easier to install and does not require in-tank tubing or wiring – see next issue for details.



By Mauro Grassi

Low-cost programmer for dsPICs and PICs

This low-cost unit can program all dsPIC30F series microcontrollers in the DIP package, along with most PIC microcontrollers. It's easy to build and uses standard parts.

PICs ARE now one of the most widely used microcontrollers. Like all micros, they greatly simplify many electronic designs, are reconfigurable in the field and allow simplification of projects that would otherwise be unwieldy or overly complex. In addition, extra features can often be added retrospectively to the firmware.

Although the PIC family of microcontrollers is well known (we have published many projects that employ PICs), Microchip also manufactures the lesser-known dsPIC30F series of microcontrollers.

These are microcontrollers with similar peripherals to those found on standard PICs, but which have an enhanced instruction set augmented with DSP (digital signal processing) type operations. They are 16-bit microcontrollers and are surprisingly powerful, running at speeds in the tens of MIPs (millions of instructions per second).

Dedicated single-cycle DSP operations like MAC (multiply and accumulate) allow them to perform real-time signal processing using multiple 40-bit accumulators. They also incorporate hardware multiplication and division, and have surprisingly fast ADC acquisition modes. These features make them well-suited to many digital signal processing applications.

One such device, the dsPIC30F4011, will feature in a new digital Musicolour lightshow project, also being published in this issue of *EPE*. This particular device can perform a real-time FFT (fast Fourier transform) on audio-band signals with ADC acquisition modes that can operate at up to 1MS/s (1 million samples per second). It runs at close to 30MIPs and has 48kB of program memory.

Programming the dsPIC30F

The dsPIC30F series of microcontrollers are extremely useful, but most older PIC programmers cannot program them. This is due to incompatibilities with the pinouts of the dsPIC family.

As a result, we have designed this simple, low-cost dsPIC and PIC programmer. It can program all the dsPIC30F family of microcontrollers that are available in a DIP package, as well as almost all regular PICs. It uses freely-available software (for the PC) and is easy to build.

By the way, if you have ever wanted to experiment with DSPs (digital signal processors), the dsPIC30F series is a good starting point. Microchip offers a lot of documentation and source code for free on their website **www.microchip.com**.

Programming procedure

Our new programmer is based on the original COM84 style programmer – so named because it was designed to program 16F84 microprocessors from

a serial port. There are really three lines which are necessary to program most PICs and microcontrollers in the dsPIC30F family: CLOCK (PGC), DATA (PGD) and V_{PP} (programming voltage).

Incidentally, the dsPIC30F family has two programming modes – enhanced and standard. The enhanced mode is faster and requires a programming executive or 'bootloader' to be programmed in first. However, this programmer uses only the slower ICSP mode that is standard across the PIC family (ICSP stands for in-circuit serial programming).

If you are interested in the details of the ICSP protocol, refer to the Microchip website at **www.microchip.com** (look for the 'memory programming specifications').

Programming mode is entered by raising V_{PP} up to around 13V. Data is then programmed into the microcontroller by serially shifting commands and data using the PGC and PGD lines.

The PGC line synchronises the exchange of serial bits, while the PGD line contains the data. The PGD line is bidirectional, allowing reading and writing of the microcontroller.

For example, there is a command code for 'Erase' which will erase the flash memory of the microcontroller. There are also commands for 'Writing' and 'Reading' pages. As soon as the microcontroller enters programming mode, it starts listening for commands.

Main features and devices supported

Features

1) Will program all dsPIC30F series microcontrollers in a DIP package
2) Will program most PICs in a DIP package
3) Uses PC freeware WinPIC for Windows
4) Connects to the serial (RS232) port of a PC
5) Very low cost

Minimum list of supported devices (others may also work)

10F series
10F200/202/204/206 (E) (*)

12F series
12F508/509 (E)
12F609/615 (E)
12F629/675 (E) (*)
12F635/636/639 (E)
12F683 (E)

16F series
16F610/616 (E)
16F627/627A/628/628A (*)
16F630/631/636/639/676/677/684/685/687/688/689 (E)
16F648/648A
16F716
16F73/737/74/76/77
16F818/819
16F84/84A/87/88 (*)
16F870/871/872
16F873/873A/874/874A/876/876A/877/877A (*)
16F913/914/916/917

18F series
18F2220/2320/4220/4320
18F2331/2431/4331/4431
18F2420/2520/4420/4520
18F2450/4450
18F2455/2550/4455/4550 (*)
18F2480/2580/4480/4580
18F2525/26204525/4620
18F2439/2539/4439/4539
18F242/252/442/452/
18F2585/4585/2680/4680
18F248/258/448/458
18F2682/2685/4682/4685

dsPIC30F series
dsPIC30F2010 (*)
dsPIC30F2011/3012 (*)
dsPIC30F2012/3013 (*)
dsPIC30F3010 (*)
dsPIC30F3011 (*)
dsPIC30F3014/4013 (*)
dsPIC30F4011 (*)
dsPIC30F4012 (*)

(*) = tested and passed. (E) = requires external connection or adaptor socket.

Circuit details

To successfully program a PIC or dsPIC series microcontroller, we must be able to control the PGC, PGD and V_{PP} lines in the correct fashion. The dsPIC/PIC Programmer achieves this by giving control of these lines to the software running on a PC. This software program is called 'WinPIC' and it makes sure that the correct procedure is followed for a particular device.

Fig.1 shows the circuit details. As can be seen, the dsPIC/PIC Programmer has two distinct supply rails (+5V and +13.6V) and these are derived from the DC supply rail using two 3-terminal voltage regulators (REG1 and REG2). Switch S1 is the power on/off switch, LED1 provides power indication and diode D1 provides reverse polarity protection.

REG2 is an LM317T variable voltage regulator. Its output is determined by the bias applied to its ADJ terminal, as determined by the voltage divider formed by the 120Ω resistor and the series 1.1kΩ and 82Ω resistors.

If R1 is the resistance between the OUT and ADJ terminals (120Ω in our case) and R2 is the resistance between ADJ and GND (1182Ω), then the LM317T will regulate its output voltage to: $V = 1.25 \times (1 + R2/R1)$. Note, however, that slight manufacturing variations mean that in practice the 1.25 factor can be anywhere between 1.2 and 1.3.

In this case, R1 and R2 have been selected so that REG2 regulates its output to 13.6V in typical conditions. This provides the $\overline{MCLR}$/Vpp voltage for the microcontroller, which should ideally be between 12.8V and 13.1V.

Parts List

1 PC board, code 754, 122mm × 120mm
1 adaptor PC board, code 755, 52mm × 19mm. Both available from the *EPE PCB Service*.
1 16V 400mA DC plugpack
1 SPDT right-angle PC-mount toggle switch (S1)
1 PC-mount 2.5mm DC power socket (CON1)
1 DB9 female right-angle socket (CON2)
1 DIP14-pin IC socket
1 DIP16-pin IC socket
2 DIP40-pin ZIF sockets
2 jumper shunts
1 8-pin DIL header with 2.54mm spacing
1 6-pin DIL header with 2.54mm spacing
1 500mm length of 0.7mm tinned copper wire
4 M3 × 6mm screws
2 M3 nuts
2 M3 × 10mm screws
4 9mm long M3 tapped spacers

Semiconductors
1 MAX232A RS232 line driver/ receiver (IC1)
1 74LS04 hex inverter (IC2)
1 BC337 *NPN* transistor (Q1)
1 BC327 *PNP* transistor (Q2)
1 7805 5V regulator (REG1)
1 LM317T Adj. regulator (REG2)
3 1N4004 diodes (D1-D3)
1 red 3mm LED (LED1)

Capacitors
1 10µF 16V electrolytic
7 1µF 16V electrolytic
2 100nF monolithic
2 22pF ceramic

Resistors (0.25W, 1%)
6 2.2kΩ   1 82Ω
1 1.1kΩ   3 39Ω
1 120Ω

However, anything from 13.4V to 13.8V is actually OK at REG2's output, since this is fed through transistor switch Q2 and series diode D2 before being applied to the $\overline{MCLR}/V_{PP}$ (master clear/programming voltage) pin of the microcontroller to be programmed.

In operation, the regulated 13.6V rail from REG2 is switched on and off by *PNP* transistor Q2, which in turn is switched on and off by *NPN* transistor Q1. When pin 3 (Tx) of the serial port is high, it will switch Q1 on, in turn switching Q2 on and applying around 13V to the $\overline{MCLR}/V_{PP}$ pin on the microcontroller to be programmed.

Conversely, when pin 3 of the serial port is low, Q1 will be off and therefore Q2 will also be off. In this case, the 2.2kΩ resistor on D2's cathode (K) will pull the $\overline{MCLR}/V_{PP}$ pin low.

Basically, on a PIC or dsPIC microcontroller, the $\overline{MCLR}/V_{PP}$ pin acts either as a Reset (0V) or a programming voltage pin (around 13V for PICs or between 9V and 13V for a dsPIC30F series microcontroller). When $\overline{MCLR}/V_{PP}$ is low, the microcontroller is in the Reset state (meaning that all its configurable pins are high impedance inputs). When it is high (around V_{DD} = +5V), the microcontroller runs in program mode, and if it is at Vpp the microcontroller will enter programming mode.

It was a deliberate design decision to switch the $\overline{MCLR}/V_{PP}$ line between 0V and V_{PP} rather than between V_{DD} and V_{PP}. This was done to avoid possible damage to the microcontroller being programmed.

To explain, if the $\overline{MCLR}/V_{PP}$ line were switched between V_{DD} and V_{PP}, the program would run on the microcontroller when programming finishes. If that program were to drive the output pins (as digital outputs or as peripheral outputs), it could cause excessive currents to flow and damage the output stages of those pins.

That's because the ZIF sockets have many power connections to accommodate different PICs and dsPICs (+5V and GND). As a result, some of the microcontroller's output pins could be shorted to +5V or to ground if the program were to run.

For this reason, the V_{PP} pin is switched from 0V to 13V so that the microcontroller is never in the running mode.

Of course, if you were to incorporate this programmer onto a PC board that catered for ICSP (in-circuit serial programming) then you would have this line switch from V_{DD} (+5V) to 13V and the reset would occur on any transition from 13V down to 5V. Refer to the section entitled 'External Programming Using CON3') for more details.

Note that some PIC microcontrollers can be configured to disable the Reset function of the $\overline{MCLR}/V_{PP}$ pin, allowing it to be used for an alternative (multiplexed) function. This should be avoided when using this programmer with a dsPIC or PIC plugged into a ZIF socket, for the reasons just outlined above (this does not apply when using CON3 to program an external device).

Regulator REG1 is used to derive the +5V rail and this is used to power IC1, IC2 and the microcontroller being programmed. This +5V rail is bypassed using 10µF, 1µF and 100nF capacitors, while a 1µF capacitor also bypasses REG1's input.

Control lines

The relevant lines used in the RS-232 serial interface to control the dsPIC/PIC Programmer are derived from pins 3, 4, 5, 7 and 8.

Pin 5 is the ground connection, while pins 3, 4 and 7 (respectively Tx, DTR and RTS) are outputs from the serial port. In particular, pins 4 and 7 are digital outputs, while pin 3 is usually the Transmit line of the serial port. These are controlled by the WinPIC software on the PC as appropriate.

Finally, pin 8 (CTS) is an input pin, and this is used to read data from the microcontroller, as required to verify or read the state of the memory.

IC1 is a MAX232 RS-232 line driver/receiver. Its job is to translate between the RS-232 voltage levels (ie, ±10V) at the serial port and the TTL levels (0-5V) used by the microcontroller. As mentioned, pins 4 and 7 of the serial port are standard digital outputs and these are connected directly to IC1.

In operation, the MAX232 actually inverts the levels, and so its outputs at pins 9 and 12 are fed to inverter IC2a and IC2f (part of a 74LS04 hex inverter) to invert them back again.

Pin 7 of the serial port controls the PGC (CLOCK) line and is applied to the microcontroller via IC1, IC2a and a 39Ω resistor (to limit the current). In addition, a 22pF ceramic capacitor is used to filter any high-frequency noise on this line.

Pin 4 controls the PGD line (DATA) output. When it goes low, so does the pin 12 output of inverter IC2f. Diode D3 allows a low level from IC2f to drive the PGD line, but blocks high-level signals from IC2f. A 2.2kΩ pull-up resistor is used instead to pull this line high. This allows the WinPIC software to read the PGD line from the microcontroller via pin 8 of the

serial port (ie, after sending pin 4 of the serial port high).

So, the PGD line is actually 'bi-directional' and is used as an output when writing to the microcontroller and as an input when reading from the microcontroller.

Note that, as with the PGC line, the PGD line is fed via a 39Ω resistor and is filtered using a 22pF ceramic capacitor to reduce spurious noise.

Two ZIF (zero insertion force) sockets are used to accept the microcontroller to be programmed. ZIF SKT1 is used for dsPIC30F series microcontrollers, and they should always be aligned with their pin 1 going to pin 1 of the ZIF socket. Alternatively, ZIF SKT2 should be used for programming standard PICs like the 16F88. As before, pin 1 of the microcontroller goes to pin 1 of the ZIF socket.

Note, however, that the 10F and 12F series of PICs are not compatible with the onboard ZIF socket. These must be programmed via an external adaptor board, as described later, or by using CON3 and a breadboard.

External programming

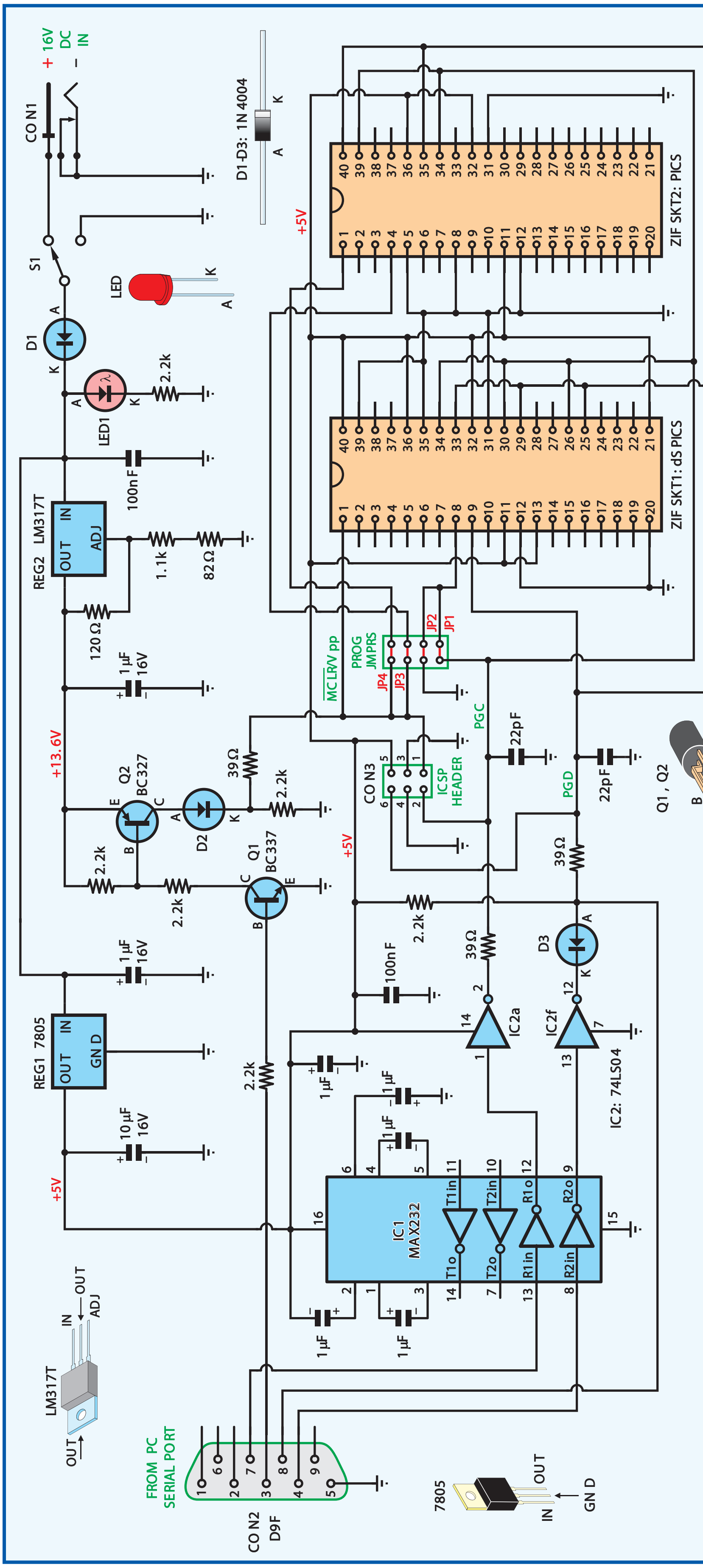
CON3 is a 6-pin header, and its pinout is arranged as shown in Table 1. It can be used to access the five relevant lines required to program both PICs and dsPICs externally (see the section entitled 'Programming via CON3').

For example, if your PIC is not actually compatible with the pinning of ZIF SKT2 (eg, if you have a PIC10F202), then you may use this connector to access the relevant lines. These lines can be connected to, say, a breadboard, to program your PIC off the PC board. Of course, you can also use this connector to program microcontrollers in circuit as well.

Jumper settings

Finally, there is an 8-pin header which accepts jumper shunts JP1 to JP4. **However, only two of the four positions should ever be shorted at any one time.** Table 2 shows the jumper functions.

In practice, you must set these according to the microcontroller being programmed. Either JP1 or JP2 (but not both) must be shorted according to the type of dsPIC being programmed in ZIF SKT1, while JP3 or JP4 (but not both) must be shorted according to the type of PIC being programmed in ZIF SKT2.



dsPIC/PIC PROGRAMMER

Fig.1: the circuit interfaces to the serial port of a PC and is based on a MAX232 RS232 line driver receiver and a couple of 40-pin ZIF sockets. Power comes from a 16V DC plugpack, with regulators REG1 and REG2 used to supply +5V and +13.6V supply rails.

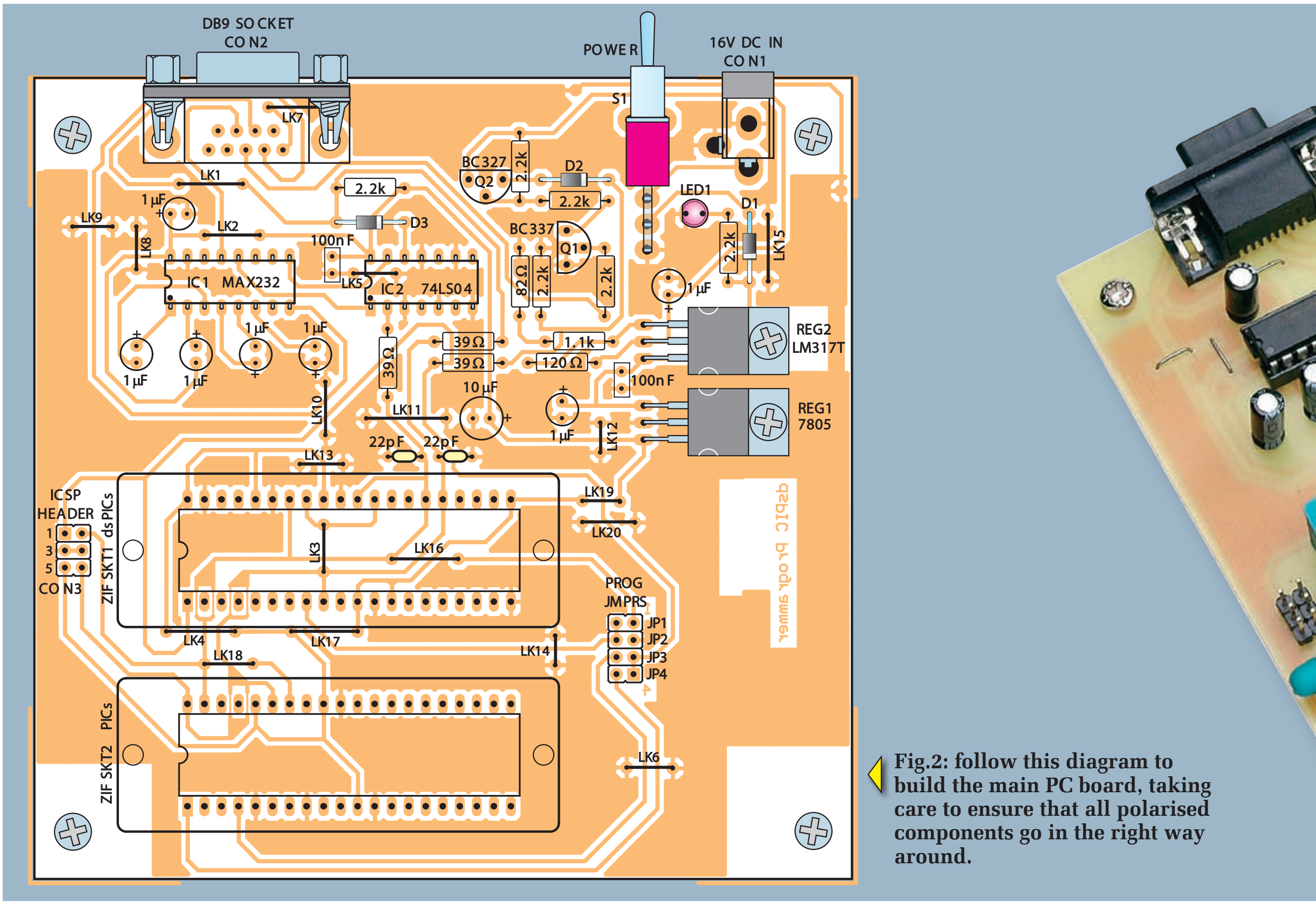


Fig.2: follow this diagram to build the main PC board, taking care to ensure that all polarised components go in the right way around.

If JP1 is shorted, it connects the PGC line to pin 8 of ZIF SKT1. This will cater for some dsPIC30Fxxxx microcontrollers that require the programming clock on pin 8. Alternatively, if JP2 is shorted, it connects pin 8 of ZIF SKT1 to ground, and this caters for the rest of the dsPIC30Fxxxx family that requires a ground connection at pin 8.

Links JP3 and JP4 select which pin the $\overline{MCLR}/V_{PP}$ programming line is connected to on ZIF SKT2. If JP3 is shorted, it connects the programming line to pin 4 of ZIF SKT2, and this suits microcontrollers such as the popular 16F88. Alternatively, some microcontrollers require the programming voltage to be applied to pin 1, and this is selected by installing JP4 instead.

Table 1: CON3 pinout

Pin	Description
1	$\overline{MCLR}/V_{PP}$
2	PGC
3	GND
4	GND
5	+5V rail (V_{DD})
6	PGD

Warning: it is quite possible to damage a microcontroller installed in either ZIF socket by incorrectly setting jumpers JP1 to JP4, so check Table 2 and Table 3 carefully before inserting a microcontroller into its socket and applying power. (Fortunately, a more likely outcome is that you will not damage the microcontroller, as they usually have protection diodes, but the programming will not be successful.

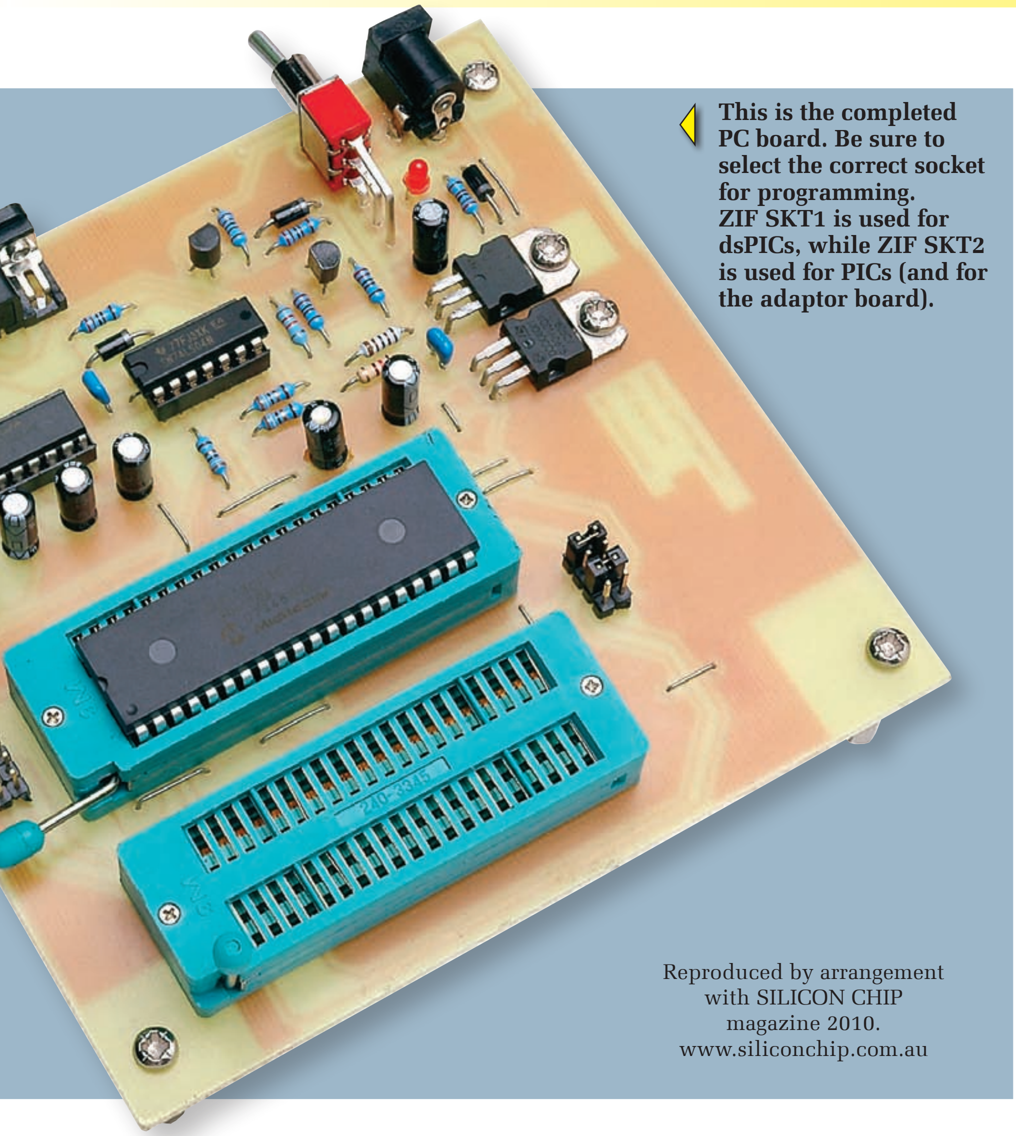
In summary, you must install either JP1 or JP2 (but NOT both) when programming a dsPIC and either JP3 or JP4 (but NOT both) when programming a PIC.

Table 2: Jumper functions

Jumper Number	Description
JP1	Short to make pin 8 of ZIF SKT1 the PGC pin
JP2	Short to make pin 8 of ZIF SKT1 GND
JP3	Short to make pin 4 of ZIF SKT2 the /$\overline{MCLR}/V_{PP}$ pin
JP4	Short to make pin 1 of ZIF SKT2 the /$\overline{MCLR}/V_{PP}$ pin

Programming via CON3

The 6-pin header CON3 can be used to program a PIC or dsPIC that's either mounted in-circuit on a separate board or installed on a breadboard. For example, this is one way of programming a PIC microcontroller that doesn't have a compatible pin-out with the ZIF sockets – see Table 3.



This is the completed PC board. Be sure to select the correct socket for programming. ZIF SKT1 is used for dsPICs, while ZIF SKT2 is used for PICs (and for the adaptor board).

Devices that fall into that category include the 10Fxxxx and 12Fxxxx series of PICs, as well as some of the 16Fxxxx series.

The pinouts for connector CON3 are shown in Table 1 and include the GND, +5V, $\overline{\text{MCLR}}$/V_{PP}, PGC and PGD lines. These are the only lines you need to program your microcontroller.

If the microcontroller is on a powered board, you can ignore the +5V line (pin 5) and simply connect CON3's GND (pin 3 or 4) to the ground of your board. It's then simply a matter of connecting the PGD lines to the appropriate pins on your PIC or dsPIC, but the $\overline{\text{MCLR}}$/V_{PP} line must be connected to the microcontroller via a diode and resistor, as shown in the panel below.

Optional Adaptor Board for 10F and 12F series PICs

We have also designed an optional adaptor board for 10F and 12F series PICs – see Fig.3. This adaptor plugs directly into ZIF socket SKT2 on the dsPIC/PIC Programmer; the position of the jumper on JP3 or JP4 is irrelevant when using the adaptor.

As shown in Fig.3, the adaptor has 20-pin and 8-pin IC sockets. The 8-pin socket is for 10F series PICs and the 20-pin socket is for 12F series PICs. As usual, the microcontroller to be programmed should be oriented so that its pin 1 is connected to the socket's pin 1. In addition, pin 1 of the adaptor board goes to pin 1 of ZIF SKT2.

You will need to refer to the microcontroller's datasheet and ensure that the pinout is compatible with the ZIF socket by referring to the schematic diagram.

Construction

The dsPIC/PIC Programmer is built on a PC board, coded 754 and measures 122mm × 120mm. The companion adaptor board is coded 755 and measures 52mm × 19mm. Fig.2 shows the main board layout, while Fig.3 shows where the parts go on the adaptor board. These boards are available as a set from the *EPE PCB Service*.

As usual, begin construction by checking the PC boards for defects, such as breaks in the tracks or shorts between adjacent tracks. It's rare to find any problems these days, but it's still a good idea to check, as defects can be difficult to spot after the parts are installed.

Once these checks have been completed, start the main board assembly by installing the 20 wire links. Use tinned copper wire for these links and make sure that they are nice and straight.

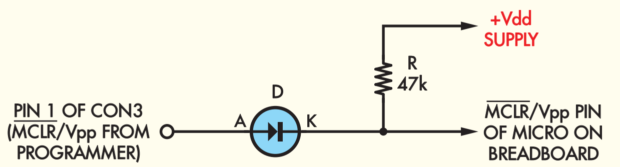
Note that link LK7 goes under the RS-232 socket (CON2), while LK3 and LK16 are under ZIF SKT1.

Follow these with the 12 resistors. Check each one using a DMM before

Using the External Programming Header (CON3)

In the circuit description of the dsPIC/PIC Programmer, we explained that the $\overline{\text{MCLR}}$/V_{PP} line was deliberately switched between 0V and +13V. This was done to avoid possible damage to the microcontroller when it is in the ZIF socket.

However, if you wish to use the external programming header (CON3) with a microcontroller on a breadboard, for example, then you should connect pin 1 of CON3 (the $\overline{\text{MCLR}}$/V_{PP} line) as shown in the accompanying diagram, adding a resistor (R) and diode (D) to the breadboard. This will allow the microcontroller to run when the $\overline{\text{MCLR}}$/V_{PP} line from the programmer is at 0V. The PGC, PGD and GND lines are connected directly to the pins on the microcontroller.



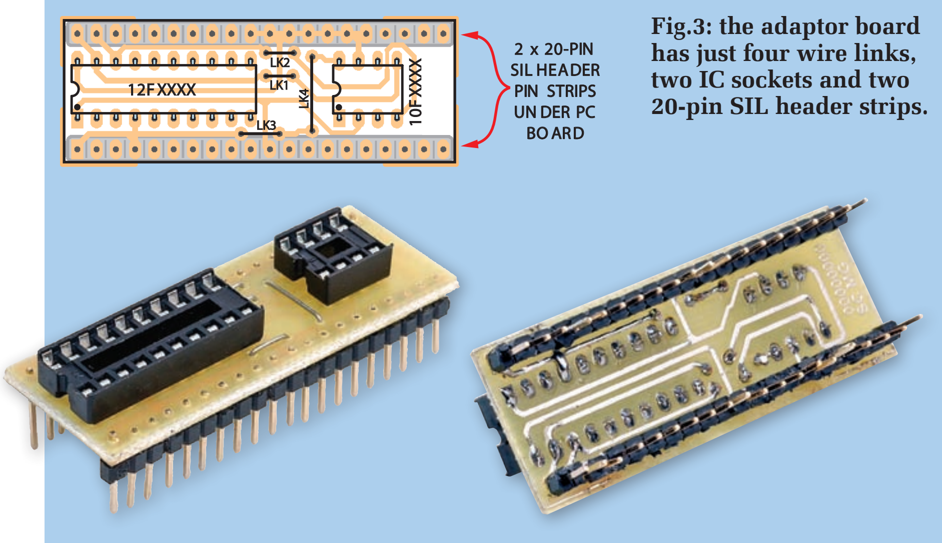
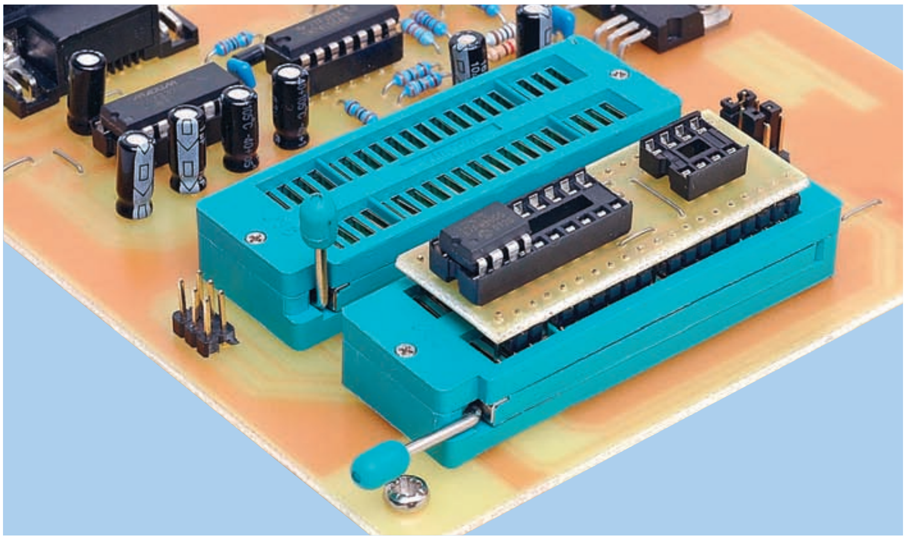


Fig.3: the adaptor board has just four wire links, two IC sockets and two 20-pin SIL header strips.



The adaptor board is used for programming 10F and 12F series PICs. As shown here, it plugs into ZIF SKT2 on the dsPIC/PIC Programmer board.

it is soldered in place, as some code colours can be difficult to decipher.

The three diodes are next on the list. Be sure to install them with the correct polarity, as indicated on the parts layout diagram (Fig.2). Once they're in, install the two transistors, again making sure that they are correctly oriented.

Don't get the transistors mixed up. Q1 is a BC337 *NPN* transistor, while Q2 is a BC327 *PNP* type. Check that each is installed in its correct location.

Now for the capacitors: the ceramic and monolithic types are not polarised and can go in either way around. However, the electrolytic capacitors are polarised, so be sure to install them correctly.

The next step is to install IC sockets for IC1 and IC2. Again, make sure that these parts go in the right way around – ie, notched ends to the right. Note, however, that these sockets are optional. **Do not install the ICs at this stage – that step comes later, after the power supply has been checked out.**

Regulators REG1 and REG2 can now be mounted. These are both installed with their metal tabs flat against the PC board. To do this, first bend their leads down by 90° about 6mm from their bodies. That done, fasten each regulator to the PC board using M3 × 10mm screws and nuts, then solder their leads.

Do **not** solder the leads before bolting the devices down, because this could crack the soldered joints and damage the PC board as the nuts are tightened. Make sure that each device is installed in its correct location.

All that remains now is to install the major hardware items. These include the 2.5mm DC power socket (CON1), the RS-232 connector (CON2), toggle switch S1, the 6-pin and 8-pin DIL pin headers and the two 40-pin ZIF sockets.

Note that the 8-pin header must be installed, but the 6-pin header is only necessary if you want to program a PIC or dsPIC externally and need access to the +5V, GND, $\overline{\text{MCLR}}$/V_{PP}, PGC and PGD lines.

Be sure to install the two large 40-pin ZIF sockets with the correct orientation. If you will only be programming a few microcontrollers occasionally, you can replace these with much cheaper IC sockets, but the ZIF sockets make life much easier (and are worth the extra money in our opinion).

Finally, secure four M3 × 9mm spacers to the corner positions of the board using M3 × 6mm machine screws. These are used to support the board off the bench top during use. If you like, you can also fit four rubber feet to these spacers.

The dsPIC/PIC Programmer is now ready for testing.

Preliminary testing

Before using this new programmer, it should be given a thorough check. **Important: do not insert a microcontroller (PIC or dsPIC) into any ZIF socket before these tests are completed.**

A 16V DC plugpack should be used to power the dsPIC/PIC Programmer, although you can also probably use a 15V DC plugpack (just). Apply power and you should see the red indicator LED light. If it doesn't, check the supply polarity, and if that's OK, check the polarity of the LED.

Assuming that the LED lights, the next step is to check the voltages at the outputs of the two regulators. You should measure +5V at the output of REG1 (anything from 4.8V to 5.1V is normal), while REG2's output should be close to 13.6V (13.4V to 13.8V is OK).

If REG2's output is lower than 13.4V, increase the value of the 82Ω resistor (eg, to 120Ω) to bring it into the 13.4V to 13.8V range. Conversely, if the output is higher than 13.8V, decrease the value of the 82Ω resistor.

Alternatively, if REG2's output is outside the designated range, check the voltage between REG2's OUT and ADJ terminals. This value can then be

used to calculate a new value for R2 from the formula given in the circuit description.

If the supply rails are correct, switch off and fit IC1 and IC2 into their respective sockets. That done, connect a serial cable between the programmer and your PC.

Adaptor board assembly

Fig.3 shows the parts layout for the adaptor board. It's a snap to assemble – just install the four wire links, the two IC sockets (watch their orientation) and the two 20-pin SIL pin headers.

Note that the pin headers are mounted on the copper side of the board. To install them, push their longer pins through until they sit flush with the top of the PC board, then initially solder just a pin at either end. The remaining pins can then be soldered, after which the plastic strips are slid down the pins until they rest against the soldered joints.

You are now ready to install the WinPIC software on your PC.

Software installation

As mentioned earlier, the software to use with this programmer is WinPIC, available from **http://www.qsl.net/dl4yhf.** Once it has been downloaded, it's installed by running the executable file *winpicsetup.exe*.

By the way, do not confuse WinPIC with other software that's available, such as WinPIC800. The latter is a completely different program and it will NOT work with this programmer.

Setting up WinPIC

After installing WinPIC, you should make sure that it is correctly set up to work with the programmer. Here's how to configure WinPIC:

1) Start WinPIC and click on the 'Interface' tab (see Fig.4)
2) Ensure 'COM84 programmer for serial port' is selected from the drop down menu
3) Ensure the correct COM port is set
4) Check that both ZIF sockets are empty and that the programmer is connected to the PC via a serial cable
5) Apply power to the programmer and click on 'Initialize!'
6) In the 'Options' tab, select either PortTalk or SMPORT (both are faster than using the Windows API). By contrast, if you wish to use a USB-RS232 converter cable, you are probably safer selecting the 'no direct access at all, only use win API' option. This will be slower, but will ensure that WinPIC accesses the correct windows drivers installed for your USB-RS232 converter. Refer to the section 'Using USB-RS232 Converters' in the accompanying panel for more information.

Using a USB-RS232 converter cable

This dsPIC/PIC Programmer is designed to work with native RS232 serial ports. However, many modern computers, especially notebooks, do not have a serial port – it has been superseded by USB.

Although USB-to-RS232 converter cables are available, not all will work correctly with this programmer. And for those that do work, programming may be considerably slower compared to working direct from a serial port.

The reason some converters don't work has to do with the low-level interface and the implementation of the USB-to-RS232 converter. In particular, the problem arises because some USB-to-RS232 converters are imperfect emulations of the serial port.

In normal use, pin 3 (Tx) of the RS232 serial port is the transmit line, used to send data at the selected baud rate. Most USB-to-RS232 converters will correctly emulate this, as it is necessary for full duplex data transmission.

However, COM84-style programmers like this one use pin 3 (Tx) of the serial port for the programming voltage, and hence as a simple digital output. This is an unconventional use of the Tx line. It is accomplished in the WinPIC software by setting the 'break' flag in the line control register (bit 6). However, some USB-to-RS232 converters (and their supplied software driver) do not emulate the break flag functionality, and therefore will not work with this programmer.

USB-to-RS232 converters based on the newer FTDI chips, especially the FT232R, could possibly work, given that the specifications claim that the FT232R has inbuilt support for line break. It is, of course, up to the manufacturer of the USB-to-RS232 converter as to whether the full features of the interface ICs are supported through the supplied software driver.

If you would like to try a USB-to-RS232 converter with this programmer, you should make sure that it supports line break and that the 'no direct access at all, only use Win API' option is selected in the 'Options' tab of WinPIC. This means that WinPIC will not access the serial ports directly, but only through the Windows API.

This ensures that WinPIC talks to the Windows driver for your USB-to-RS232 converter, rather than trying to access ports that are not implemented. As indicated above, this may result in substantially slower operation than with a native serial port.

In our case, we tested the Prolific GUC-AD9 USB-RS232 converter on Windows XP and it worked. The only drawback was that it was slow – up to ten times slower than when running the programmer direct from a serial port.

This is related to latencies in the Windows API and the Windows driver for the converter. A small delay (in the order of milliseconds) occurs when switching any control line and these small delays all add up to a considerable delay due to the huge number of switching requests made by WinPIC.

Note: the Prolific GUC-AD9 USB-RS232 converter is available from Jaycar (Cat. XC4834).

Programming a PIC: a step-by-step guide

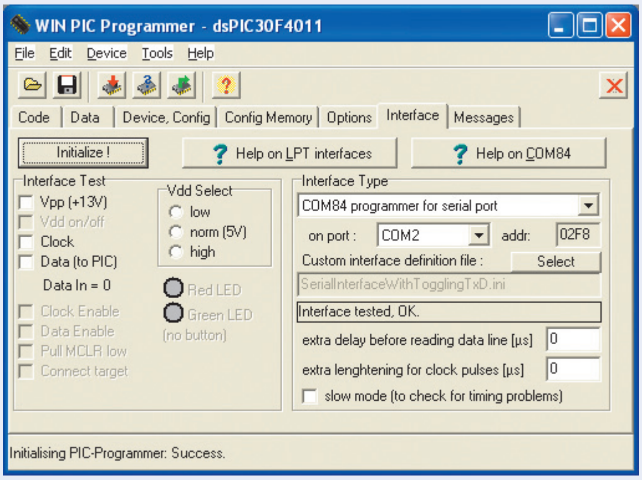


Fig.4: clicking the Interface tab in WinPic brings up this window. Ensure 'COM84 programmer for serial port' is selected for the Interface Type and be sure to choose the correct COM port.

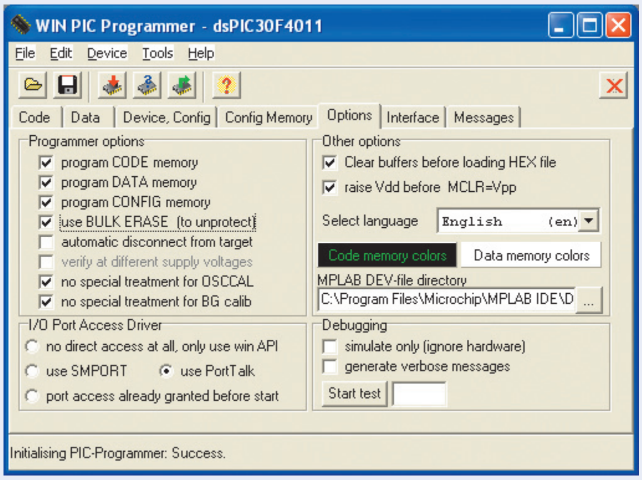


Fig.5: after selecting the device to be programmed (see text) go to the Options tab and select the options shown here. The dsPIC or PIC can then be programmed as outlined in step 4.

Once the programmer has been initialised correctly by WinPIC, you are ready to program some PICs. Here's the procedure, step-by-step:

1) Check that the power is off, then insert the PIC or dsPIC you wish to program into its corresponding ZIF socket (according to Table 3).

2) Set the jumpers as per Table 3. Note that either JP1 or JP2 (but NOT both) must be installed for dsPICs. Likewise, JP3 or JP4 (but NOT both) must be installed for PIC microcontrollers, as set out in the table.

   If these jumpers are incorrect, programming will almost certainly fail.

3) Once the jumpers have been set, apply power, then start WinPIC, go to **Device > Select** and select the PIC or dsPIC you wish to program from the drop down menu. That done, go to the 'Options' tab and select the options, as shown in Fig.5.

4) To program the dsPIC or PIC, go to **File > Load > Program Device** and select the hex file to be programmed. Note that the fuse bits should be within the hex file, and they will be programmed as well.

WinPIC should now start to program your device and then verify its contents. You can use the 'Code' tab to see the program memory.

If programming is successful, you should see the message 'Programming finished, no errors' at the bottom lefthand corner of the window.

You can also erase, read and verify a microcontroller using WinPIC, although you should keep in mind that reading a code-protected device will result in zero readings for the program memory bytes. For more information on how to use WinPIC, refer to its help menu.

Finally, note that WinPIC accesses the serial port on your PC and requires real-time control of the programming signals. It is therefore possible that it will lock up while programming is in progress, and fail to respond to mouse or keyboard commands.

To prevent this, avoid having other Windows programs running in the background while WinPIC is programming a device. If the WinPIC window stops responding when programming a device, simply wait for it to finish.

If everything is working correctly, you should see the message 'Initialising PIC-Programmer: Success' at the bottom of the WinPIC window, as shown in Fig.5.

Troubleshooting

If you receive the message 'WARNING: Could not initialize programmer!' instead, you can test the interface manually to narrow down the list of possible problems. Here's what to do:

1) Clicking the 'V_{PP}(+13V)' box should toggle pin 1 of CON3 (the external programming header) from 0V (box unticked) to around 12.5V to 13V (box ticked). If this doesn't happen, check that transistors Q1 and Q2 are the correct types. If they are, trace the signal from pin 3 of the serial port to pin 1 of CON3, checking at each stage that the signal toggles as this box is 'ticked' and 'unticked' in WinPIC.

2) Clicking on the 'Clock' box should toggle pin 2 of CON3 from 0V (unticked) to around 4V to 5V (ticked).

   If that doesn't happen, check the MAX232 and its surrounding capacitors. That done, check the signal at pin 7 of the serial port, then at pins 13 and 12 of IC1, pin 1 of IC2, pin 2 of IC2 and finally pin 2 of CON3.

   Note that the MAX232 (IC1) should level translate the signal level at pin 13 to about +5V at pin 12.

3) Clicking on the 'Data (to PIC)' box should toggle pin 6 of CON3 from 0V to around 3.5V to 5V, and you should see the 'Data In=' field change from 0 to 1. The latter should be 0 with the box unticked and 1 otherwise.

   If this is not the case, check the signal at various points on the circuit from pin 4 of the serial port to pin 6 of CON3. Check also that pin 8 of the serial port is receiving the correct level (read by WinPIC and displayed in the 'Data In=' field).

Read the FAQ

Finally, if the programmer is still not working, there could be issues with WinPIC. Refer to the online FAQ at **http://www.qsl.net/dl4yhf/winpic/winpic_faq.htm** as a

Table 3: Setting jumpers JP1/JP2 and JP3/JP4

Device	ZIF socket	JP1	JP2	JP3	JP4
10F200/202/204/206	Ext	N/A	N/A	N/A	N/A
12F508/509	Ext	N/A	N/A	N/A	N/A
12F609/615	Ext	N/A	N/A	N/A	N/A
12F629/675	Ext	N/A	N/A	N/A	N/A
12F635/636/639	Ext	N/A	N/A	N/A	N/A
12F675	Ext	N/A	N/A	N/A	N/A
12F683	Ext	N/A	N/A	N/A	N/A
16F610/616	Ext	N/A	N/A	N/A	N/A
16F627/627A/628/628A	ZIF SKT2	N/A	N/A	Short	Open
16F630/631/636/639/676/677/684/685/687/688/689	Ext	N/A	N/A	N/A	N/A
16F648/648A	ZIF SKT2	N/A	N/A	Short	Open
16F716	ZIF SKT2	N/A	N/A	Short	Open
16F73/737/74/76/77	ZIF SKT2	N/A	N/A	Open	Short
16F818/819	ZIF SKT2	N/A	N/A	Short	Open
16F84/84A/87/88	ZIF SKT2	N/A	N/A	Short	Open
16F870/871/872	ZIF SKT2	N/A	N/A	Open	Short
16F873/873A/874/874A/876/876A/877/877A	ZIF SKT2	N/A	N/A	Open	Short
16F913/914/916/917	ZIF SKT2	N/A	N/A	Open	Short
18F2220/2320/4220/4320	ZIF SKT2	N/A	N/A	Open	Short
18F2331/2431/4331/4431	ZIF SKT2	N/A	N/A	Open	Short
18F2420/2520/4420/4520	ZIF SKT2	N/A	N/A	Open	Short
18F2450/4450	ZIF SKT2	N/A	N/A	Open	Short
18F2455/2550/4455/4550	ZIF SKT2	N/A	N/A	Open	Short
18F2480/2580/4480/4580	ZIF SKT2	N/A	N/A	Open	Short
18F2525/26204525/4620	ZIF SKT2	N/A	N/A	Open	Short
18F2439/2539/4439/4539	ZIF SKT2	N/A	N/A	Open	Short
18F242/252/442/452/	ZIF SKT2	N/A	N/A	Open	Short
18F2585/4585/2680/4680	ZIF SKT2	N/A	N/A	Open	Short
18F248/258/448/458	ZIF SKT2	N/A	N/A	Open	Short
18F2682/2685/4682/4685	ZIF SKT2	N/A	N/A	Open	Short
dsPIC30F2010	ZIF SKT1	Open	Short	N/A	N/A
dsPIC30F2011/3012	ZIF SKT1	Short	Open	N/A	N/A
dsPIC30F2012/3013	ZIF SKT1	Open	Short	N/A	N/A
dsPIC30F3010	ZIF SKT1	Open	Short	N/A	N/A
dsPIC30F3011	ZIF SKT1	Short	Open	N/A	N/A
dsPIC30F3014/4013	ZIF SKT1	Short	Open	N/A	N/A
dsPIC30F4011	ZIF SKT1	Short	Open	N/A	N/A
dsPIC30F4012	ZIF SKT1	Open	Short	N/A	N/A

Ext = use an external programming header or the adaptor board.

first resort if you are experiencing problems.

Because WinPIC tries to switch the programming lines in real time and because Windows is a multi-tasking operating system, timing problems could arise. For this reason, it is prudent to use the 'slow mode' option in the 'Interface' tab if you suspect there may be timing problems.

EPE

Recycle It!

BY JULIAN EDGAR

Getting the good bits out of old washing machines

Any washing machine built in the last 10 years is worthy of salvaging for its internal parts. Here's what you'll find inside.

WASHING machines have changed a lot over the years. While a typical washing machine used to be a top-loading, belt-driven design with mechanical timer controls, more recent machines include technology such as direct-drive, fully electronic controls and plenty of wiring. And those aspects make any washing machine built in the last 10 years worthy of salvaging for its internal parts.

For this story, we pulled apart two front-loaders, but in the past we've also disassembled plenty of top-loader machines.

Motors

All washing machines have a powerful electric motor inside. Most machines are belt-driven; that is, they use an electric motor that's easily removed and can then be used as a standalone motor to drive anything you want – from a workshop sander to a fan.

However, with the very low price of new electric motors, this type of electric motor may or may not be worth salvaging. If grabbing the motor, don't forget to get a starting capacitor, if it is fitted.

Alexander, our apprentice of the month! You're never too young to learn that the items that people throw away contain plenty of good bits worth salvaging

Some washing machines use a very special, large diameter, direct-drive motor. These can be removed, complete with the stainless steel shaft and bearings, and then used as a wind generator, water generator or even brushless DC motor. Doing a web search under 'Fisher and Paykel motor generator' will yield sites that describe how these motors can be easily modified to achieve excellent outcomes. And, if you decide you don't want it, these motors are worth money secondhand.

Pumps

The electric pump from a washing machine is usually quiet, relatively low power (eg 30W or 40W), can handle hot water and has a removable lint filter. These characteristics make the pumps excellent for circulating water in a solar water heater or for low pressure water transfer.

If using a pump in this way, you **must** ensure that the wiring is appropriately insulated and earthed, and that water cannot come in contact with it.

Solenoids

There are two – and sometimes three – solenoids in each washing machine. The solenoids are electrically operated valves that control water flow. Most washing machines use 230V (ie mains power) solenoids, while some (eg Fisher and Paykel) use 12V solenoids.

The solenoids can be used whenever mains-pressure (or lower) water supply needs to be turned on and off. The lower voltage solenoids can be easily and safely used to control water flow in a variety of applications, including

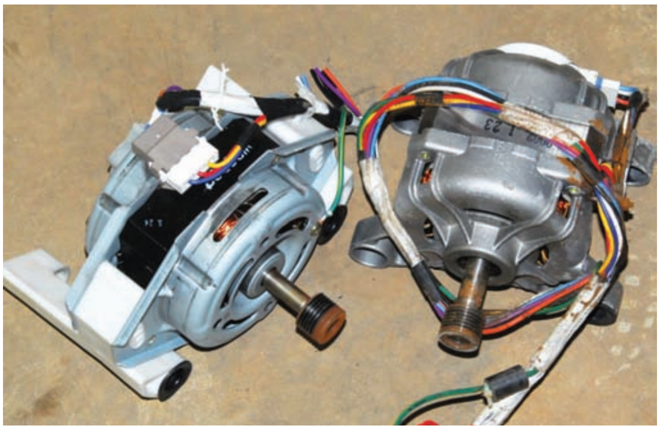
We pulled apart these two front loading washing machines. However, any machine of the last decade contains a great mix of electronic and mechanical parts

solar water heating systems, gardening or recreational vehicles. They will cope with high water pressures and are usually leak-proof. *The mains-powered solenoids must only be used in insulated surroundings.*

Water level sensor

Older washing machines use a mechanical pressure switch to detect water level. The adjustment in water level is achieved by altering the spring preload. These switches are simple to use, high current, very sensitive and are always worth salvaging.

More modern machines use a variable output electronic design water level sensor. That sounds good, but most of these sensors appear to use an iron core moving within encapsulated electronics – and I haven't found a



If you need a mains-powered powerful electric motor, a washing machine will provide it for you! These are belt-drive motors, but some machines contain direct-drive motors that can be modified to become wind generators and the like

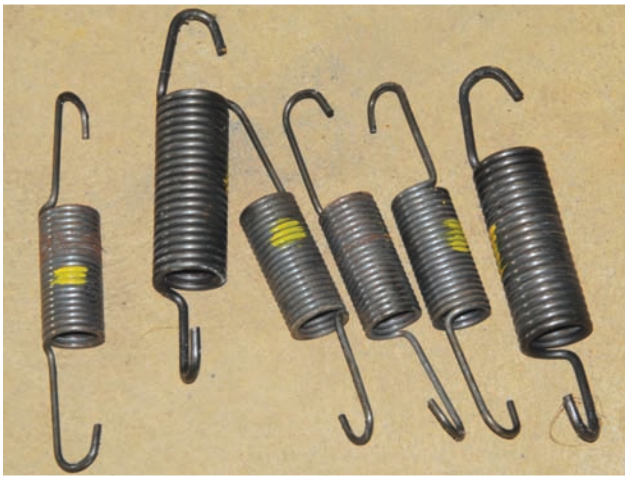
All washing machines contain mains-powered pumps. They're quiet, use little power, can handle hot water and have removable filters. That makes them ideal for water transfer and solar water heating applications

The water control solenoids from washing machines are well worth salvaging, especially if they're 12V designs. Note, however, that like the one shown here, most are mains powered

Believe it or not, all these LEDs, the push-button switches and the rotary encoder were salvaged from the control panels of just two washing machines!

In many washing machines you'll find a stainless steel temperature sensor. These are usually NTC resistance designs that can be used in many applications. Note that the soap scum shown on this sensor was simply wiped off

Why buy different colours and gauges of hook-up wire when you can get them for nothing?



There's also plenty of hardware to be found in washing machines. Hardware like these springs...

...spring clips...

...rubber hoses...

...and screws (including stainless steel)

simple and effective way to interface with them.

Temp sensor

Many washing machines now incorporate heater elements to allow higher water temperatures than can be provided by the domestic water heater. These machines use a temperature sensor to monitor the water and they are excellent parts to grab, being of stainless steel construction and with quite a quick reaction time.

They use an NTC design, where the resistance falls as temperature rises. As such, they are suitable for temp sensing in a wide range of applications.

Electronic components

Most of the electronics in washing machines are 'potted' – that is, the boards are covered with a thick layer of rubbery plastic, waterproofing them. It's pretty well impossible to salvage components from these boards.

However, the control panel is usually not potted. By placing the control panel board in a vice and aiming a heat gun at the solder side, a pair of pliers can be used to quickly and easily pull salvageable components from the boards. In this way, it's possible to salvage parts in literally seconds. Parts likely to be available include LEDs, switches and rotary encoders.

Hardware

There is a surprisingly large amount of hardware in many washing machines. Much of it is of high quality: stainless steel self-tapping screws, heavily plated machine screws, and – in front-loaders – many long self-tapping hex-headed bolts (they hold the drum halves together).

Because the washing machine tub has to cope with out-of-balance loads, most machines also incorporate springs to allow the tub lateral movement (top loaders) or vertical movement (front-loaders). These springs are heavy duty and are well worth salvaging.

You'll also find a variety of rubber hoses and spring clips. Finally, there's usually plenty of wiring of different gauges and colours – perfect whenever you need a short length of hook-up wire.

Conclusion

By the time you discard the cabinet, bowl (stainless steel – so worth money at the scrap yard), internal weights and other bulky parts, the remaining good bits can be stored in literally a shoebox... so it's not like the salvaged parts of a washing machine take up much space.

But it's even better if you sort the parts – LEDs into an appropriate drawer in the electronic parts cabinet, self-tapping bolts with your other self-tappers, and so on. Then, next time that you go looking for these components, you magically find that you've got plenty to pick from! ***EPE***

Matrix Multimedia MIAC Review

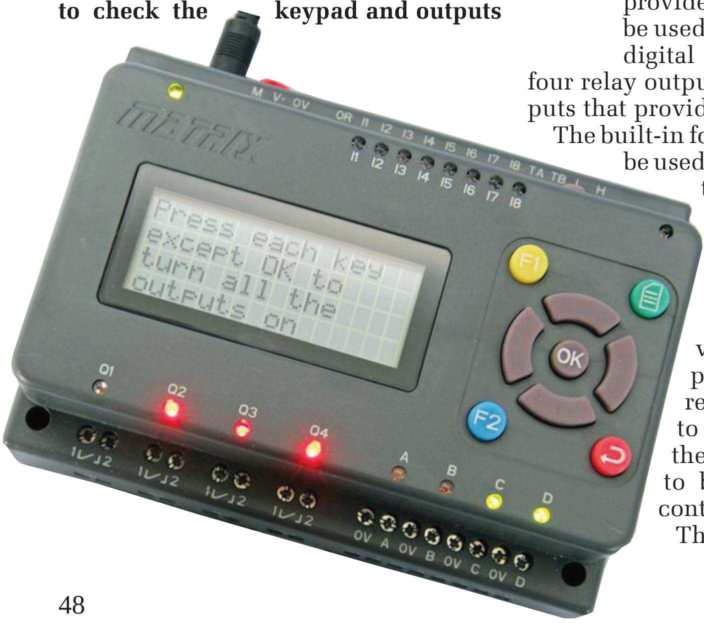
by Robert Penfold

You don't have to be a programming expert to drive MIAC, as Robert reports

The MIAC (Matrix Industrial Automotive Controller) from Matrix Multimedia is an industrial grade controller that is based on an 18-series PIC microcontroller. It is housed in a tough plastic case and is designed to be equally rugged electrically. It has a Controller Area Network (CAN) interface that enables the development of systems based on two or more MIACs.

Although units such as this are generally described as controllers, there are plenty of inputs as well as outputs, and it is equally suitable for sensing applications. The MIAC can be programmed using C, assembler, or Matrix Multimedia's own Flowcode (flowchart based) programming language. Flowcode is now up to edition 4, but it is a version of Flowcode 3 that is included with the MIAC.

Fig.1. The built-in test program makes it easy to check that the MIAC is operating correctly. This is the first section of the test program, which is used to check the keypad and outputs



Ins and outs

Connections to the unit are made via a number of heavy-duty screw terminals, and a very useful set of inputs and outputs are provided. An eight-bit port can be used to provide analogue or digital inputs. There are also four relay outputs and four motor outputs that provide speed control.

The built-in four-line LCD screen can be used to display data and status information, and the status of the inputs and outputs is shown by sets of red and green indicator lights. The unit can be controlled via a nine-button keypad, and there is also a reset button. In addition to its obvious function, the latter sometimes has to be pressed to initiate contact with the host PC.

The unit is connected to a PC via a USB port for programming purposes. It is not powered from the PC, and once programmed, it no longer needs to be connected to the PC. With no PC detected, the unit will automatically run the program stored in its memory. Power is provided by a mains adapter, and a suitable unit is available as an optional extra. However, the MIAC has been designed to be very flexible in this respect, and many users will already have something suitable.

A DC supply of 12V to 16V is needed, and the current rating should be at least 250mA. A higher current rating of up to 2A is needed if the MIAC will be used to supply large output currents to motors or other loads. The power port is a standard 2.1mm type, and the polarity of the power source is unimportant, which greatly reduces the risk of 'blowing' the unit with an inappropriate adapter. An alternative way of supplying power to the unit is to connect it (**with the right polarity**) direct to the 0V and V+ screw terminals.

Getting started

Getting under way with the MIAC is reasonably straightforward, and initial checking of the unit is very easy. Installing the driver software for the MIAC is simplified by the inclusion of an installer program. Installation of Flowcode 3 follows along the normal lines for Windows programs. The only

problem encountered was that it would not even get through the initial stages of installation when I tried to use it with a PC running Windows Vista, although it loaded without difficulty on another Vista PC, and on PCs running under Windows XP and Windows 7.

The Flowcode CD-ROM comes complete with a temporary product key that lasts for only 30 days. After this period, the program becomes a trial version with numerous limitations unless it is registered. Registration is free, and it simply involves going to the Matrix Multimedia website (**www.matrixmultimedia.com/MIAC-X.php**) to get a user name and full product key. This seems unnecessarily involved, but registration does not require the user to divulge any personal information other than a valid email address, to which the user name and product key will be sent.

Flowcode

The MIAC is supplied with a simple test program preinstalled, and this will run automatically with the unit powered up, but not connected to a PC. The first stage of the test routine is used to check that the various buttons, the four digital outputs, the four relay outputs, and the eight output indicator lights are functioning correctly (Fig.1). The second section is used to test the eight inputs, with readings from the inputs being displayed on the LCD. This is a nice feature that makes it easy to check that the unit is basically sound before moving on to the next stage and trying to program it.

It is possible to program MIAC units using assembler, C, or Flowcode, but it is likely that most of the unit's target 'audience' will prefer Flowcode to the intricacies of C or assembler. Flowcode has featured previously in *EPE* on more than one occasion, so it will not be described in great detail here.

The basic idea is to produce a flowchart for the program, with any necessary parameters such as the times in delay loops being included. Flowcode is then used to compile the information in the flowchart into a fully working program. This is in the form of a hex file that can be used to program the PIC chip in the MIAC unit.

Program building

Building the program using Flowcode is very easy, and it is just a matter of dragging various building-blocks from the palette down the left-hand side of the screen into the flowchart in the main panel until the required program is built up (Fig.2). Editing charts is also easy because the elements in a

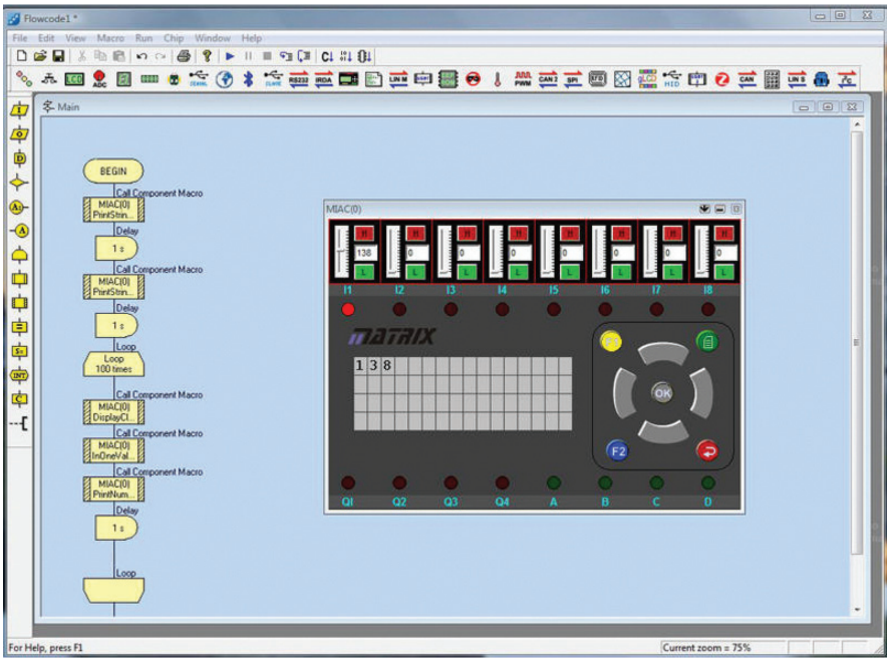


Fig.2. The large main panel is the drawing area. A flowchart is built up by dragging blocks from the palette down the left-hand side of the screen into the appropriate positions on the drawing area

chart can be dragged into new positions, or simply deleted if they are no longer needed.

Double-clicking a building-block brings up its properties window, and parameters for that block can then be set. In the case of an output instruction, for example, the correct port and bit of that port must be selected, and then the required state for that bit is chosen.

Flowcode has some additional features and components that are specific to the MIAC unit. The target chip has to be selected before compiling the code, and here the MIAC option is selected, and not the PIC chip used in the MIAC. There is a MIAC component that can be displayed on the screen (Fig.3), and this enables programs to be run in simulation mode. This enables most programs to be debugged, or at least largely debugged, prior to uploading them for real-world testing. The buttons on the unit can be operated by left-clicking them, the indicator lights and LCD are simulated, and so on.

Unfortunately, the virtual MIAC unit did not display correctly with Flowcode running on two of the test computers, with the bottom and right-hand side of the unit being severely clipped. This rendered it of little practical value with those PCs. The problem seems to be caused by the font DPI size being something other than the default value, and it can be cured by returning this setting to its default value.

The onscreen simulation is only one aspect of the MIAC component, which also provides a component macro. This gives the user easy access to routines that make it easy to use the MIAC hardware. The MIAC macro is accessed by dragging the component macro block onto the flowchart, double-clicking it to

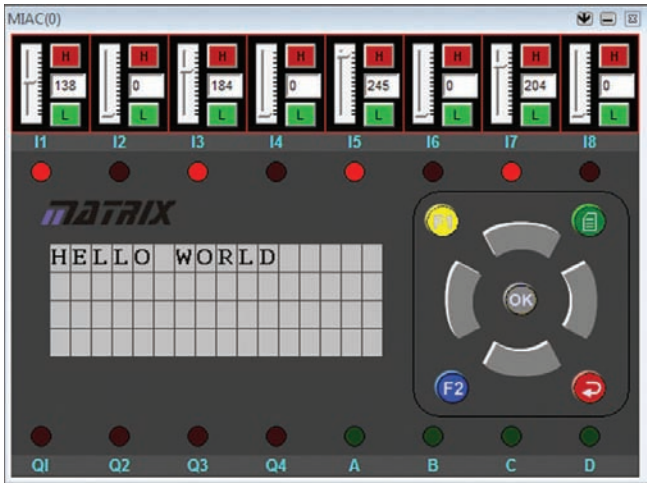


Fig.3. The MIAC component is used when running program simulations. The row of slider controls near the top are used to set suitable input levels, and they can be altered while a simulation is running

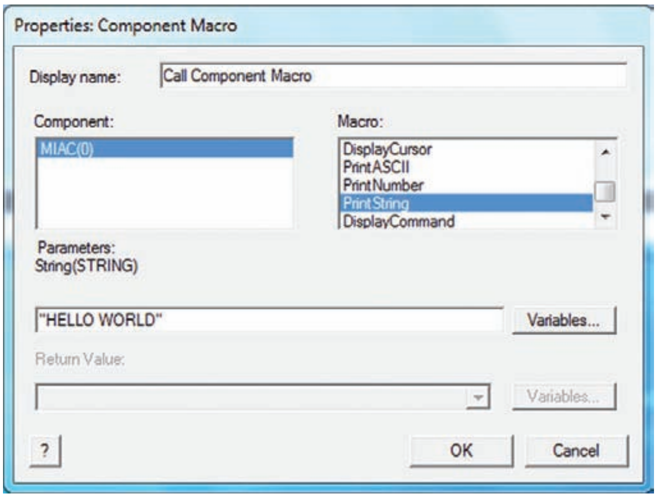


Fig.4. A range of MIAC-specific instructions can be obtained by adding a component macro and selecting the MIAC macro from the list (which only has one entry in this example). Some of the additional facilities make it easy to use the built-in LCD, and in this example a text string is being written to the display

bring up the properties window, and selecting the MIAC macro. It is then possible to use a range of instructions that are specific to the MIAC, such as one that makes it easy to display text strings on the LCD (Fig.4).

Documentation

As tends to be the case with most computer-related equipment nowadays, there is no printed manual supplied with the MIAC, or even a printed Quick Start guide. However, the software CD-ROM includes an 18-page Quick Start Guide for the MIAC, and a 12-page guide to help get Flowcode 3 installed and under way. These are well produced and in full colour, but only cover a few basics and are limited in scope. They are in PDF format, and can be viewed using the Abobe Reader program, which also enables them to be printed if a 'hard copy' version is required.

Some relatively simple example programs are installed with Flowcode, and some more advanced programs can be obtained from the Matrix Multimedia website. This site also has a number of tutorial videos that cover Flowcode. The Flowcode guide will get you started, but it will be necessary to study the example programs and use the additional tutorials in order to fully master this programming language.

The MIAC guide covers the initial installation, setting up, and testing of the unit. It also includes some useful information about the hardware on the inputs and outputs of the unit, including such things as the overload protection on the inputs, and their transfer characteristic when used in the analogue mode. The section on programming the unit is quite brief, with just one example, and the inclusion of one or two additional Flowcode examples specifically for the MIAC unit would be helpful.

The Flowcode installation includes a utility called MiacProg that is used to program the MIAC from a hex file. This can be used independently with hex files produced using the Flowcode program, or by other means. However, it can also be used from within Flowcode using the Compile to chip icon or menu option.

The MIAC must be powered up and connected to the computer, and contact must have been established with the MiacProg utility. If necessary, the user is prompted to operate the MIAC's Reset switch to initialise contact, and the transfer of the program then goes ahead.

Conclusion

The MIAC is well made and it certainly gives the impression of being rugged enough for operation in tough situations. It has a good range of inputs and outputs, but obviously some applications will require more than its eight inputs and eight outputs.

I did not give the CAN interface a full test, but using this method to link two units it is possible to double the number of inputs and outputs, and if necessary even more units can be added to the system. Apart from the one or two teething problems with the Flowcode program mentioned previously, everything worked reliably during the test period.

Although the MIAC is primarily intended for use in fairly heavy-duty industrial applications, it provides an easy way of implementing a system based on a microcontroller. As such, the MIAC is potentially of interest to educational users and hobbyists as well.

It is not cheap, but the cost is reasonable for a unit of this quality, and it has to be remembered that you get a fully working copy of Flowcode 3 as well. With the aid of Flowcode it is possible to get the unit functioning effectively in a wide range of applications without having to become a programming expert first. The MIAC-specific extensions to Flowcode make it reasonably easy to use facilities of the unit such as the LCD and analogue inputs, and to simulate programs.

Cost

The MIAC costs £120 excluding VAT and postage. An A-to-B USB cable and mains adaptor are required, and are not included as standard.

Further information about the MIAC can be obtained from:

Matrix Multimedia Ltd, Dept *EPE*, The Factory, 23 Emscote Street South, Halifax, West Yorkshire, HX1 3AN, UK

Tel: +44 (0)1422 252 380

Fax: +44 (0)1422 252 381

Website: www.matrixmultimedia.com/MIAC-X.php

Email: justin@matrixmultimedia.co.uk

Postscript

Having read the review, Matrix's technical team have offered the following comments:

Quoting Robert – 'The problem seems to be caused by the font DPI size being something other than the default value...'

Matrix – The DPI issue has been resolved in Flowcode 4 (not supplied).

One of the things that Robert did not pick up on is that it is also possible to use the MIAC as a USB terminal from a PC – to make it a slave for visual Basic or other applications. Flowcode has quite cool routines for several types of USB communication.

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Hells Bells and Decibels

JOE posted the following question about decibels on the *EPE Chat Zone* forum (**www.chatzones.co.uk**)

I'm hoping that one of you audio/maths people can help me with this as I've done some research and I'm not the smarter for it to be honest. I know that the dB for audio isn't linear, so that 20dB isn't 100% louder than 10dB. However, is there a simple-ish way to calculate in real terms, how much louder a 101dB sound is, compared to a 94dB sound?

We will start by looking at sound and decibels in the context of sound measurement, and then also look at the use of decibels in electrical signal measurement.

Sound measurement

Sound is measured in two ways; first by *sound intensity*, which is the power per unit area in a given direction, measured in watts per square meter (Wm^{-2}); and second by *sound pressure*, which is force per unit area, measured in pascals (Pa). Microphones and ears respond to sound pressure, so this measurement is generally more relevant in audio electronics work.

Neither sound pressure nor sound intensity is the same as loudness. Loudness relates to the perception of sound and thus is both physical and psychological in nature. The study of the perception of sound is called psychoacoustics.

The human ear is able to hear sounds over a very large range of sound levels. The quietest sound which can be perceived is called the threshold of hearing and has an intensity of 1×10^{-12} Wm^{-2}, corresponding to sound pressure level of 20μPa (micropascals). The threshold of pain is about 10,000,000,000,000 times more than this in intensity terms at about 10 Wm^{-2}, corresponding to a sound pressure around 3,160,000 times greater, at about 63Pa. These threshold figures are only approximate as sound perception varies between individuals and with frequency, so you may see different values quotes in other articles.

As perceived

A linear increase in sound pressure (or intensity) is perceived as a logarithmic increase in loudness. This is illustrated in Fig.1, which plots the value of sound pressure in decibels against the original value in Pascals. The decibel value gives a very approximate indication of perceived loudness.

An exponential increase in sound pressure (or intensity) from the quietest audible to the loudest tolerable sound is perceived by us as a basically linear increase in perceived loudness. This is illustrated in Fig.2, which again plots the decibel value of sound pressure against the value in pascals, but this time using a logarithmically scaled axis for the original value. Again the decibel value can be taken as a crude indication of perceived loudness. Here we see, for example, that a tenfold increase of sound pressure gives an equal step increase in loudness.

The nature of the exponential response means that small changes in sound pressure at relatively low average sound pressure levels are as significant as large changes are at much higher average levels. Plotted on a linear graph, the details at low levels will be lost. The ratio of values (largest to smallest) of sound pressure plotted on Fig.1 is ten thousand to one, although the smaller 'loudness' values are effectively impossible to discern. Fig.2 covers a much larger ten million to one ratio of values which are all equally readable. Also, the vast range of pressure values makes the numbers difficult to appreciate, whereas the decibel 'loudness' values are more manageable.

By definition

The definition of a decibel (dB) is based on the logarithm of the *power* ratio of two sounds (or signals) P_1 and P_2, such that the power ratio in decibels is given by $10\times\log_{10}(P_2/P_1)$ dB, where P_1 is the agreed reference level (say the threshold of hearing) and P_2 the value we are measuring. Because power *ratios* are used in the decibel definition, it does not matter if P_1 and P_2 are expressed as peak or average values as long both are expressed in the same way.

The term decibel means one tenth (*deci*, hence d) of a *bel* (symbol B). One bel is $\log_{10}(P_2/P_1)$, but as we use $10\times\log_{10}(P_2/P_1)$ we are counting in tenths of a bel. The bel is named after Alexander Graham Bell.

If the value we are interested in is equal to the reference we get 0dB. If the measured power is twice the reference level we get +3dB ($10\times\log_{10}(2)$), if it is half we have –3dB. A negative decibel value represents a power smaller than the reference, not 'negative power' (whatever that might be). A tenfold increase in power over the reference level is 10dB, a million times the reference level is 60dB. The threshold of pain is 130dB above the threshold of hearing; using the figures above: $10\times\log_{10}(10/1\times10^{-12})$ = 130dB. Joe mentions two dB figures, 94dB and 101dB,

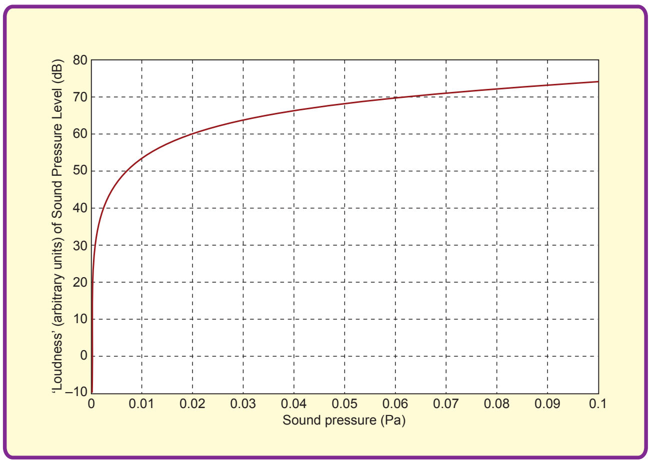


Fig.1. Sound pressure in decibels plotted against sound pressure in pascals. The decibel value gives an approximate indication of perceived loudness

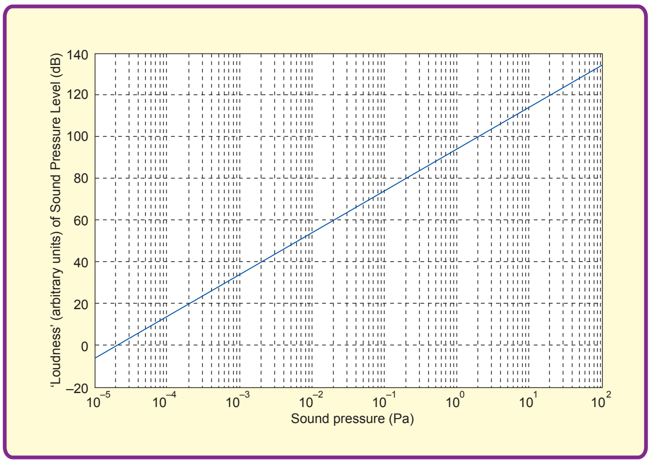


Fig.2. Sound pressure in decibels plotted against sound pressure in pascals using a logarithmic scale for the value in pascals. The decibel value gives an approximate indication of perceived loudness

this is a difference of 7dB. This represents a power ratio of $10^{(7/10)} = 5.0$. So a change from 94dB to 101dB represents a fivefold increase in sound intensity.

The pressures on

So far, we have only discussed power ratios – this is appropriate for sound intensities (measure in watts per square meter), but not for sound pressure. Sound intensity is related to the square of the sound pressure. If we square something inside a logarithm it is equivalent to multiplying the log by two (without the square). That is $\log(x^2) = 2\log(x)$. So to express a sound pressure ratio (p_1/p_2) in decibels we use $20\times\log_{10}(p_2/p_1)$. Note that we are multiplying by 20, not by 10 as we did with the power ratio. So we have

$$20\times\log_{10}(p_2/p_1) = 10\times\log_{10}(P_2/P_1)$$

Where p_1 is the sound pressure of the reference level, P_1 is the sound intensity of the reference level, p_2 is the sound pressure of the measured level and P_2 is the sound intensity of the measured level.

If a measured sound pressure is twice the reference level we get +6dB ($20\times\log_{10}(2)$), if it is half –6dB. A tenfold increase in sound pressure over the reference level is +20 dB, a million times the reference level is +120dB. The threshold of pain is 130dB above the threshold of hearing; using the figures above: $20\times\log_{10}(63/2\times10^{-5}) = 130$ dB. Note that this is the same figure as we got from the sound intensities, the different formula for dB intensity and pressure make sure this happens.

Looking at Joe's values again, 94dB and 101dB; the difference of 7dB represents a sound pressure ratio of $10^{(7/20)} = 2.24$. So a change from 94dB to 101dB represents a bit more than a doubling in sound pressure level. Note that the change from 94dB to 101dB is the change between the same two 'sounds' in both cases, but the pressure and intensity scale differently because of the square-law relationship between them (note $2.24^2 = 5$).

While sound intensity and pressure are both rigidly defined, and thus we are able to give a precise answer to Joe's question in those terms, loudness is a matter of human perception and will vary between individuals and with the frequency and time behaviour (rate and direction of change) of the sounds listen to. Thus, if Joe is referring to perceived loudness the answer to his question, *'is there a simple-ish way to calculate in real terms, how much louder a 101db sound is, compared to a 94db sound'*, is no.

Psychological

Perceived loudness can be measured psychologically, by asking people to judge the loudness of sounds played to them. One approach to this is to ask people to judge when a sound is twice as load as the reference sound. Such experimental work indicates that a perceived doubling/halving of loudness typically corresponds to a sound pressure change by a factor of around ×3.16 or 10dB, however this varies quite a bit deepening on the environment, type of sound and individuals involved.

Another way to approach sound measurement psychologically is to play a sound at a reference frequency and ask the subject to adjust the volume of a sound at another frequency so that the perceived loudness of the two sounds is equal. Such measurements have been used to produce standard curves

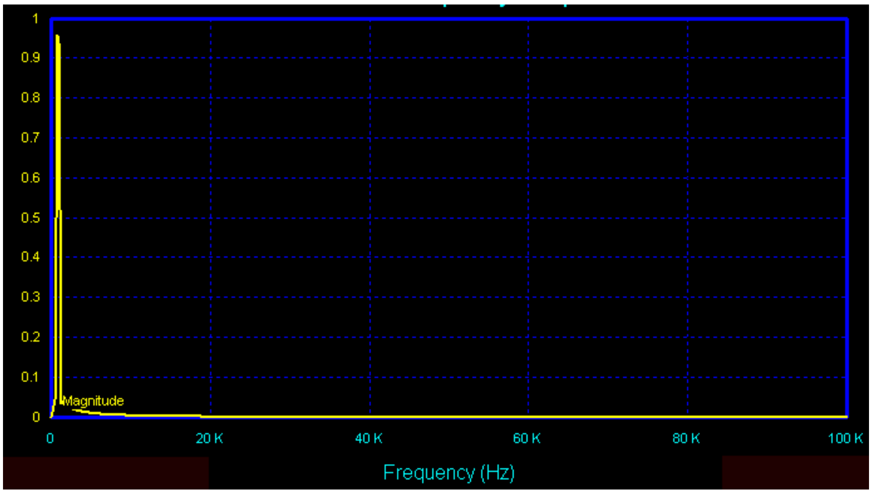


Fig.3. Frequency response characteristics of bandpass filter for the range 10Hz to 100kHz plotted with linear gain and frequency scales

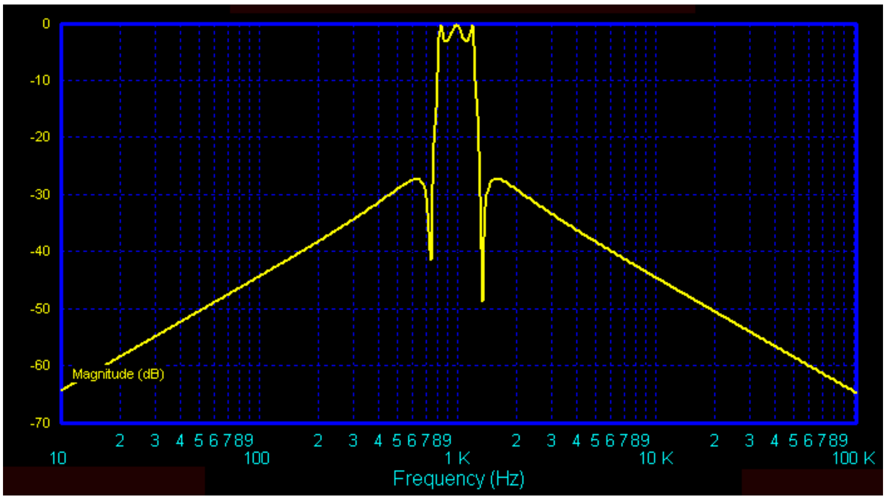


Fig.4. Frequency response characteristics of same bandpass filter as in Fig.3, plotted over the same frequency range but using logarithmic gain and frequency scales

for variation of human hearing with frequency, referred to for many years as 'Fletcher–Munson curves', after the names of the first authors to publish such curves (in 1936). The term 'Normal equal-loudness-level contours' is now preferred and the curves are standardised as ISO 226:2003 (the 2003 version is the most recent of several versions of the ISO 226 standard). The web page for the standard is **www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=34222**.

Phons and sones

Psychoacoustic investigations lead to proposals for units of measurement of loudness called **phons** and **sones**. One phon is defined as being equal to a sound pressure level of 1dB (above threshold of hearing) at a frequency of 1kHz. At 1kHz the phon value and sound pressure value in dB are equal, at other frequencies they diverge and one has to consult equal-loudness contours to convert between phons and decibels. One sone is defined as 40 phons and the sone scale is defined so that a doubling of loudness measured in sones corresponds to a doubling of perceived loudness. Conversion between sones and phons can be done as follows:

phons value $= 33.2 \times \log_{10}(\text{sones value}) + 40$

sones value $= 10^{(0.03\times(\text{phons value} - 40))}$

The human ear is most sensitive in the range of approximately 1kHz to 4kHz. Thus, to get closer to a measurement of perceived loudness sound pressure meters often use filters which approximate the average human hearing response. There are a number of standard filters used for this purpose, but perhaps the most well known is known as the dBA scale, which is most accurate for relatively low sound levels.

Voltage and power gains

The decibel is also used to express voltage and power gains in circuits and for standardised electronic signal level measurements, for example in audio systems. We will take a brief look at both of these topics to round off our coverage of the decibel.

The power gain of a circuit is the ratio of output to input powers, P_{in} and P_{out}, which, like sound intensity, can be expressed in decibels using $10\times\log_{10}(P_{out}/P_{in})$ dB. Note that gain is already a ratio of two values, so we do not need to define a reference level to state gain in dB.

Power is related to the square of voltage so, in a similar way to sound pressure (as opposed to intensity), we express a voltage gain (V_{out}/V_{in}) in decibels using $20\times\log_{10}(V_{out}/V_{in})$. Note again that we are multiplying by 20, not by 10. Strictly speaking, this formula is only valid if the two voltages are applied across the same value of impedance, but in many cases we

are only interested in the voltage gain (not the power gain) and the $20\times\log_{10}(V_{out}/V_{in})$ formula is widely used for this purpose. Similarly, current gains can be expressed in decibels using $20\times\log_{10}(I_{out}/I_{in})$.

If a circuit reduces power, ie it is an attenuator, then the we get negative decibel values for its gain. For example, if the power output is 50 times smaller than the input the gain is –17dB. If the power is reduced by one half then the output is at –3dB. This is a figure that many readers may be familiar with as the cut-off frequency of a filter (or the bandwidth of an amplifier) is usually quoted as the point when the gain falls to 3dB below the value in the pass-band. At this frequency the output power from the filter is half the value it is in the pass-band (for equal input power).

The usefulness of using log scales for graphs is illustrated by Fig.3 and Fig.4, both of which show the frequency response characteristics of the same bandpass filter over the same frequency range. Fig.3 uses linear scales and Fig.4 uses the conventional logarithmic scales for gain (dB) and frequency.

Signal level

Gains in decibels are relatively easy to understand because the ratio is input to output, but for measuring signal level we need to make sure we know what reference level we are dealing with and whether it is power or voltage measurement. If we work with matched systems, where the input and output impedances are all basically the same, then it makes sense to measure signals in power terms (the matching achieves maximum power transfer).

This was the case with the old 600Ω matched systems. For the signals in these systems one milliwatt was a convenient reference level for decibel power measurement, so the unit dBm (or dBmW) was used for this purpose. Given an impedance of 600Ω, the 1mW reference power corresponds to a voltage of 0.775V (RMS). This is easily verified using $P = V^2/R = 0.775^2/600 = 0.001$mW.

Under these conditions, it made sense to use 0.775V RMS as a reference level for decibel voltage measurements. We have to use a different unit for this as dBm is a power measurement not a voltage measurement so dBu (or dBv) is used.

As with other voltage-based decibel measurements, the resistance may be ignored or unspecified, although the dBu unit is often stated as referring to an open circuit situation, that is 'unloaded' or 'unterminated', hence the u. Note that 0.775V RMS is about 1.1V peak (not 1.0V) for a sinewave signal, the value 0.775V RMS relates to power into a 600Ω load and not conversion from peak to RMS voltages.

If you are not using a 600Ω system then, apart from its historical precedence, the 0.775V RMS reference level seems very arbitrary. For this reason a reference using the 'round number' of 1V RMS is sometimes used instead. The symbol for this is dBV. 1dBV is equal to 2.2dBu (from 20*log10(1/0.775)) and 1dBu is equal to –2.2dBV (from 20*log10(0.775/1)). The impedance is not specified for dBV measurements.

There are a couple of standard signal levels used for audio equipment. These are +4dBu and –10dBV. +4dBu, which is typical for professional audio equipment is 1.23V RMS (from $0.775\times10^{(4/20)}$, or check that 20log(1.23/0.775)=4). –10dBV, which is typical for consumer equipment, is 0.316V RMS (from $1\times10^{(-10/20)}$, or check that 20log(0.316/1) = –10). Meters on audio equipment will typically be calibrated to these levels (eg, 0dB on the meter is +4dBu or 1.23V signal).

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

THE values used in electronics can be a little confusing for newcomers, and I suppose that one reason for this is simply that the units of measurement used are unfamiliar. You do not drive five farads to work or buy a two-kilohms bag of sugar! Fortunately, there are only a few new types of measurement to deal with, and most electronics hobbyists soon come to terms with them.

Another slight complication is that the quantities used in electronics are often very small or very large. You do not drive 50 terametres to work or buy a picogram bag of sugar. When building an electronic project, you could well be using a ten-million ohm resistor one minute and a 0.0000001 farad capacitor the next.

Resistors and capacitors are both available in a very wide range of values, with the highest values in common use being at least one hundred million times higher than the lowest. However, the values of electronic components conform to the normal metric conventions and are not difficult to master.

Massive resistance

The basic measurement of resistance is the *Ohm*, and one ohm represents quite a small amount of resistance. The physically small resistors used in most electronic projects are generally available with values from about one ohm to 10 million ohms, but values down to around 0.1 ohms are also available.

Physically larger resistors that are designed to dissipate high power levels are only available in relatively low values, again going down to 0.1 ohms. Special high value components, having resistances of 100 million ohms or more are manufactured, but they must be handled and used carefully if their accuracy is to be maintained, and they are little used in practice.

The Greek letter omega (Ω) is used to indicate that values are in ohms, and a 47Ω resistor has a value of 47 ohms. In a modern computerised world there can be practical difficulties with anything other than normal alphanumeric characters. Therefore, an upper case letter 'R' is often used in place of omega. Accordingly, a value of 47 ohms might appear on a circuit diagram or in a components list as either '47Ω' or '47R'. In fact, it might even be written as just '47'.

With component values, it is now standard practice for the character denoting the unit of measurement to also indicate the position of the decimal point. A 3.9 ohm resistor would therefore have its value given in the form of '3Ω9' or '3R9'.

When dealing with higher value resistors, the prefixes 'kilo' and 'mega' are used. In the metric system these respectively denote one thousand and one million of something. A kilometre is a thousand metres, and a kilohm is a thousand ohms. The abbreviation for kilohm is 'kΩ' or just 'k', and the abbreviation for megohm is 'MΩ' or just 'M'. I suppose that strictly speaking it should be 'megaohm' rather than 'megohm', and perhaps even 'kiloohm' instead of 'kilohms', but in practice it is definitely megohms and kilohms.

As with lower value resistors, the letter indicating the unit of measurement is used as the decimal point as well. A value of 8.2 kilohms would normally be written as '8k2', and a value of 5.6 megohms would be written as '5M6'.

Band of gold

High power resistors and a few smaller types have the value written on the body, together with a tolerance rating or code letter. Resistors having a power rating of about one watt or less almost invariably use colour coding to indicate the value and tolerance rating. The standard four-band coding uses the method shown in Fig.1. Table 1 shows the meaning of each colour, but several colours are only used in some bands. Band 1 is close to the end of the body, and in some cases is right at one end of the body. Band 4 is well separated from the end of the body.

As an example of a colour code, suppose a resistor has bands that are yellow, violet, red, and gold. Bands 1 and 2 indicate the first two digits of the value, which in this example are yellow (4) and violet (7). The first two digits of the value are therefore '47'. The third band provides the multiplier value, and in this example it is red (×100). This gives a final value of 47 × 100, which is 4700 ohms or 4.7kΩ (4k7). The fourth band is gold, which means that the tolerance rating is plus or minus 5%.

Some resistors have a fifth band that indicates the component's temperature coefficient. With these, it is a matter of just

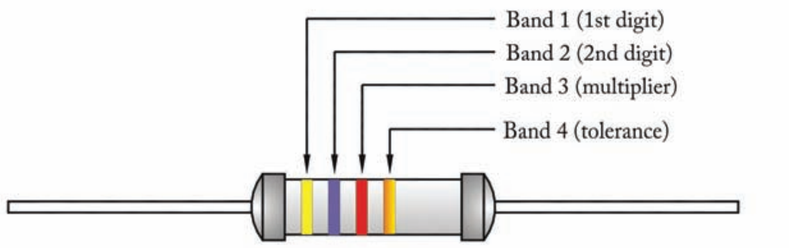


Fig.1. The values of small resistors are normally marked using a four-band colour code. In this example the value is 4.7 kilohms (47 × 100 = 4700 ohms or 4.7 kilohms (4k7))

Table 1: Four-band Resistor Colour Code

Colour	*Band1/2*	*Band 3*	*Band 4*
Black	0	x1	-
Brown	1	x10	1%
Red	2	x100	2%
Orange	3	x1000	-
Yellow	4	x10000	-
Green	5	x100000	0.5%
Blue	6	x1000000	0.25%
Violet	7	-	0.1%
Grey	8	-	-
White	9	-	-
Gold	-	0.1	5%
Silver	-	0.01	10%
None	-	-	20%

ignoring the fifth band and using the first four in the normal way. There is another five band version of the resistor colour code that uses the first three bands to provide the first three digits of the value, with the other two bands indicating the multiplier and tolerance rating. Fortunately, these are a rarity, but they do turn up from time to time.

High capacity

The basic unit of capacitance is the *Farad*, but this is a massive unit by normal electronic standards. After about 50 years in electronic project construction I have never used anything larger than a 0.0047 *Farad* capacitor, and most projects use nothing beyond a 0.0001 farad component.

The values of large capacitors are normally expressed in *microfarads*. The metric system uses 'micro' as a prefix that means 'a millionth of', and one microfarad is therefore equal to a millionth of a farad. A 0.00047 farad capacitor would normally have its value given as 470 microfarads.

The Greek letter mu (µ) is used as the abbreviation for micro, but a lower case letter 'u' is often used instead. In a components list, or on a circuit diagram, a 22 microfarad capacitor would therefore have its value given in the form '22µF' or '22uF'. Actually, this value would often be given as just '22µ' or '22u', and the 'F' is not really needed since the values of capacitors are always given in farads.

At just a millionth of a farad, a microfarad might seem to be a very small amount of capacitance, but by normal electronic standards it still represents a substantial quantity of capacitance. It is certainly too large for use with small and middle value capacitors. These usually have their values expressed in *nanofarads* or *picofarads*.

A nanofarad is one thousandth of a microfarad, and a picofarad is one thousandth of a nanofarads. A picofarad is therefore equal to one millionth of a microfarad, or one trillionth of a farad. Capacitors of just a few trillionths of a farad are sometimes used in electronic circuits, and are actually quite common in radio equipment.

Of course, the nano, and pico prefixes are not only used for capacitance values, and they are the standard metric prefixes used to respectively indicate a thousand-millionth, and a trillionth of something. The size of the droplets used by inkjet printers is expressed as so many 'picolitres' for example.

The lower case letters 'n' and 'p' are respectively used as the abbreviations for nanofarads and picofarads. A value of 680 picofarads would therefore be marked as '680pF' or just '680p' on a circuit diagram. In the same vein, a value of 15 nanofarads would be marked as '15nF' or '15n'. As with resistors, in order to conserve space on crowded circuit diagrams, the values are usually condensed by having the decimal point indicated by the letter that indicates the unit of measurement in use. For instance, values of 6.8 picofarads and 4.7 nanofarads are often given as '6p8' and '4n7' respectively.

Letter of the law

The value markings on capacitors can be something less than obvious at first glance, and some are decidedly cryptic. While a 270 picofarad capacitor might have its value shown as '270p', it is quite likely to be marked as 'n27'. In other words, it is a 0.27 nanofarad capacitor (0.27n), and 0.27 nanofarads is the same as 270 picofarads.

There is a similar problem with capacitors having values from about 10 nanofarads to 820 nanofarads. A '470n' capacitor could be specified in a components list, but this value could be expressed as 0.47µF in component catalogues, and possibly on the component itself.

This is most likely to occur with electrolytic and tantalum capacitors, which tend to have their values given in microfarads regardless of how large or small the value happens to be. Some ceramic capacitors also have their values marked in microfarads (Fig.2 left).

There is another form of cryptic capacitor marking that uses a three digit number, such as '273', and does not include a letter. With this system the value is always in picofarads, and it mainly used with fairly low value components. However, it is sometimes used for middle value components.

The first two digits in the value marking are simply the first two digits of the value. The third digit is the multiplier, and it indicates the number of 'zeros' that must to be added to the first two digits in order to give the full value.

For example, a capacitor marked '273' has '27' as the first two digits of the value, and three zeros must be added to these in order to provide the complete value. The capacitor, therefore, has a value of 27000 picofarads (pF), or 27 nanofarads (27nF). The component in Fig.2 (left) has a value of 470 picofarads (470pF). This system is essentially the same as the one for marking resistor values, but with numbers marked on the component instead of a system of colour coding.

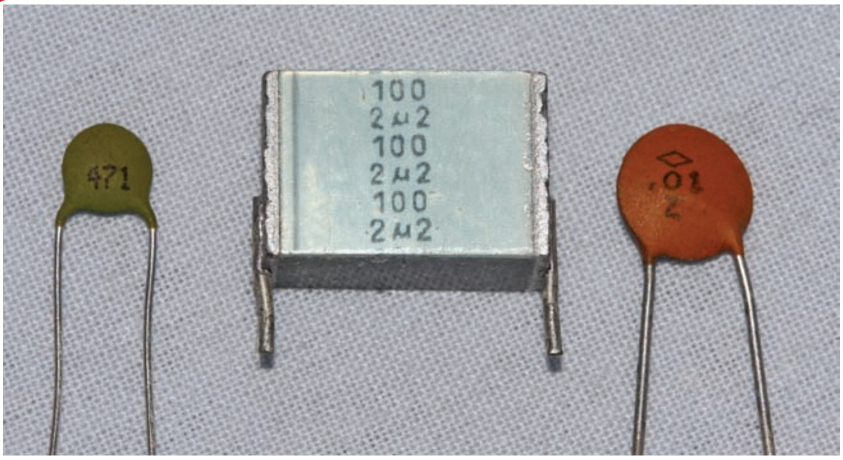


Fig.2. The value of the ceramic capacitor on the left is 470 picofarads (47 with a multiplier of one zero = 470 picofarads (470pF)). The capacitor in the middle has a value of 2.2 microfarads (2µ2) and a maximum working voltage of 100V. The value of the ceramic capacitor on the right is 0.01µF, or 10nF

Letter imperfect

At one time it was common for some types of capacitor to have their values marked using colour coding. The coding usually included other information such as the voltage and tolerance ratings. The basic method used was based on the colour coding system used for resistors.

Although it might seem like an unnecessary complication, there is a big advantage in using colour codes. Minor damage to the markings still leaves the value perfectly readable, but the same is not true with components that are labelled with tiny lettering. Anyway, colour coding is still used with some other components, but it has not been used with capacitors for many years and is unlikely to be encountered these days.

Electronic components are often marked with numbers and letters that are of no real significance. These are usually things like batch numbers or the date of manufacture in some highly cryptic form that is only understood by those making the components. Capacitors are not immune to these unhelpful and potentially confusing markings, but they sometimes have markings that provide useful information. For instance, the maximum voltage and tolerance ratings are sometimes included.

The tolerance is simply the maximum amount by which the actual value of the component will differ from the marked value. The tolerance is sometimes marked on capacitors using a code letter. These are the tolerance ratings for the common code letters:

Code Letter	*Tolerance*
F	+/- 1%
G	+/- 2%
H	+/- 3%
J	+/- 5%
K	+/- 10%
M	+/- 20%

Choked up

Colour coding is also used with some small inductors, which are also known as 'chokes'. The basic unit of inductance is the *Henry*, and one henry is a very large amount of inductance. Therefore, most inductors have their value expressed in microhenries (µH), which are millionths of a henry. The larger inductors have the value given in millihenries (mH), which are thousandths of a henry.

The system of colour coding used for inductors is essentially the same as the one used for resistors, but it gives a value in nanohenries (nH). Divide the value in nanohenries by one thousand to obtain a value in microhenries, or by one million for an answer in millihenries.

For example, suppose an inductor has the colour code blue, grey, orange, and silver. The first three colours provide a figure of 68000 (68 × 1000), and dividing this by one thousand gives a value of 68 microhenries (68µH). The silver band indicates that the component has a tolerance rating of plus or minus ten percent.

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Chameleon PIC 16-Bit Development Kit

BEFORE getting into our own PIC and Propeller hardware design, let's take a look at an existing hardware platform from Nurve Networks. The Chameleon PIC 16-Bit Development Kit is the latest of many development systems to come from the Nurve Networks stable.

Nurve is known for their 'retro' games development systems (we reviewed one last year, the XGS PIC), but this offering is somewhat different – it's designed as a general purpose embedded controller system intended to be used as the computing and display output part of a larger project. They believe it can find uses from student projects or hobbyist platforms up to process controller solutions. With its low cost and novel features, we thought we would take a look.

At first glance, the controller looks straightforward. It's a small PCB (printed circuit board) just larger than a credit card, with a generous prototyping area (ideal for hobbyists) that can be snapped off. A number of 0.1-inch SIL headers are fitted to provide digital I/O and analogue inputs. Their positioning is such that an extension board can be neatly placed over the board, maintaining a compact solution.

It's something of a surprise to find there are no mounting holes for securing the PCB, so mounting it inside a case will be a bit of a challenge.

In addition to the usual processor I/O connections, the board comes with some interesting connectors – a mini-USB socket for RS232 communications to a host; a PS/2 interface for mouse or keyboard; phono sockets for audio and composite video; plus a standard VGA socket for driving a monitor. This is what makes the Chameleon such an interesting device – a low cost general purpose microcontroller system with full video output capabilities. We'll go into this in more detail in a moment.

Inside the box

The kit is supplied in a simple DVD case (see Fig.1), which is quite a nice touch as it meant the packaged arrived through the letter box, avoiding the necessity for a trip to a collection office. Inside, the contents as shown in Fig.2 are simple – the PCB; a prototyping breadboard to place over the prototyping area on the PCB; an LED for simple experiments; and a DVD containing over 1.5GB of information. You will have to supply a 7.5V to 9V DC regulator, a sensible choice as most of us have these to hand or are readily available locally. The shipment cost for a 'power brick' is probably close to the cost of one of these from Asda or Walmart anyway.

Fig. 1 The Chameleon Development Kit comes in a DVD-size case

Processing power

No programming unit is supplied; the device uses a 'bootstrap loader' to load software over the USB-based serial port. You will also need to supply a mini-USB cable for this, but again these are readily available. Headers are provided for connecting a Microchip PICkit programmer if you wish to bypass the bootloader, and a male-to-male header strip is provided for this purpose.

Looking at the PCB (Fig. 3) reveals the unusual nature of the Chameleon – it comes with two processors. A 16-bit PIC24HJ128GP502 running at 40MHz, and a Parallax Propeller chip running at 80MHz. We discussed the Propeller processor last month, but for those who are unfamiliar with the device, it's a 32-bit processor with *eight* processing cores, each clocked at 80MHz. This is a powerful system, with nine processors providing over 200MIPS raw processing power.

Two systems in one

The Chameleon is effectively two development systems in one: a Microchip PIC24 system – a fast, 16-bit processor, with 128KB of flash that can be programmed in C or assembly. Second, a Parallax Propeller system that provides video and audio output. Each system can be treated as independent, and we were indeed able to run several Propeller demonstration games without the PIC24 being involved. A switch on the PCB allows the USB serial interface to be switched between the two processors for independent application load, and the various headers provide both PIC and Propeller I/O signals.

The real power comes from the combination of the two processors. The Propeller can achieve some very complex tasks, but is ultimately limited by the 32KB

Fig. 2 The kit contents consist of the PCB, a plug-in prototyping 'breadboard', an LED, pin header strip and a DVD containing over 1.5GB of information

memory. In the Chameleon, the Propeller acts by default as a 'media processor', providing the video and sound output for the PIC processor.

The PIC, with it's much larger 128KB flash, can concentrate on providing the application that drives these features, typically written in the 'C' programming language. There is also a huge range of industrial and control software freely available for the PIC, which nicely compliments the software available for the Propeller.

When tying two processors together in a design, it's important that you have good communication between them. Nurve Networks have devised a fast communication protocol between the PIC and the Propeller processors to assist with high bandwidth data, such as display updates. The protocol is discussed at length in the DVD manual and is itself an excellent introduction to the subject.

I/O connections

The I/O signals are all provided on 0.1-inch single in-line (SIL) headers, but unfortunately the headers are not themselves spaced on a 0.1-inch grid – meaning that any board connecting to more than one header strip will need to be

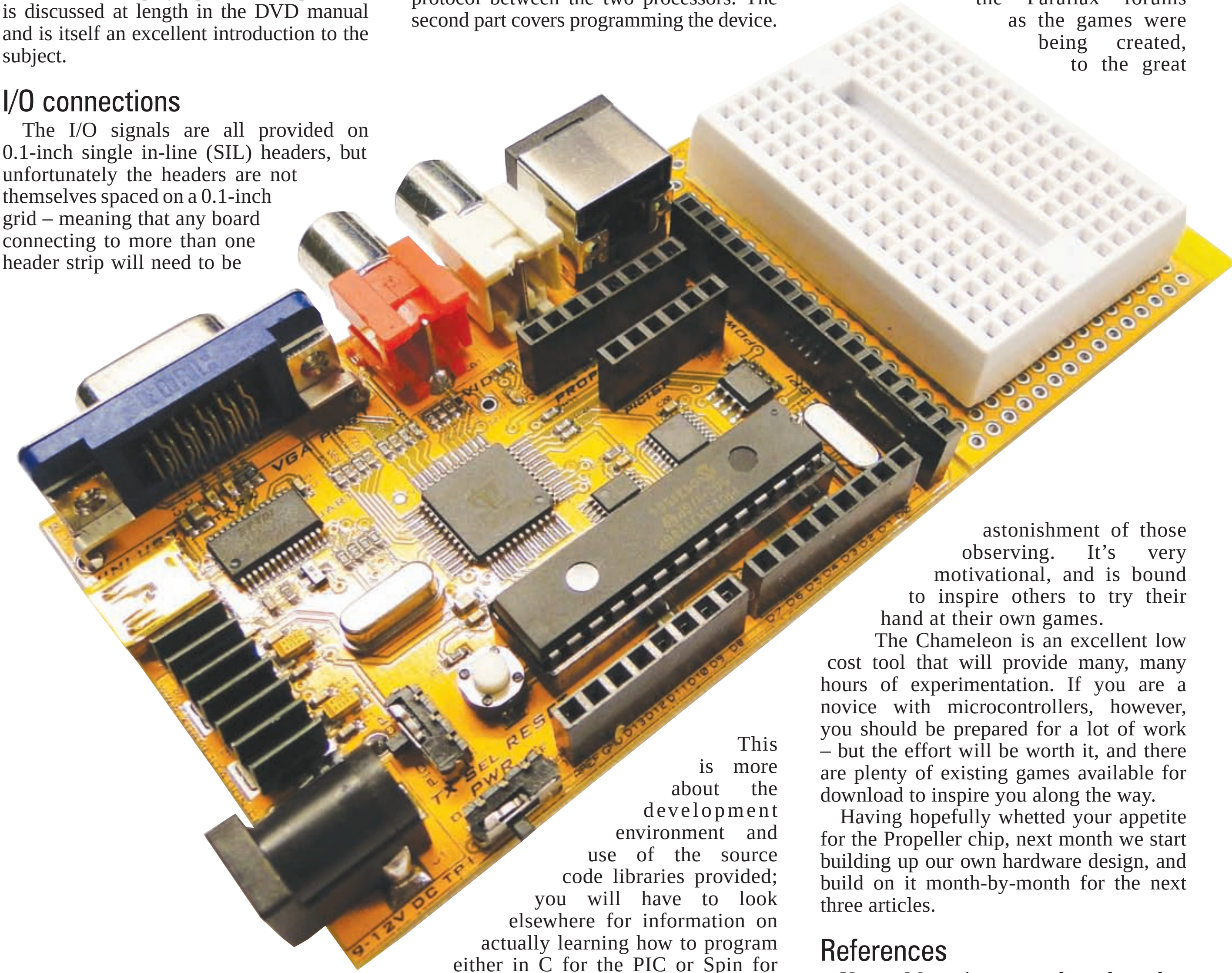


Fig. 3. The PCB, with prototype area attached at one end. It comes with two on-board processors: a PIC24HJ128GP50C, running at 40MHz and a Propeller chip running at 80MHz

custom made. This is easy enough to do, but it would have been nice to be able to build add-on circuits with off-the-shelf square pad matrix boards. Overall though the positioning is excellent and allows for a very compact stacked PCB arrangement. (We are already planning a dual game controller add-on board.)

A large number of the PIC's I/O signals are available, including the full 16-bit PORTB and several analogue inputs from PORTA. There is also a separate header for a PICkit 2/3 programmer, should you wish to bypass the pre-loaded bootloader. There are fewer pins available from the Propeller – just eight – but this is due to so many pins being used for the external connectors. The propeller is, after all, intended to be a slave 'media' interface to the PIC, so this is unlikely to be an issue.

User manual

A 263-page combined user manual and programming guide is provided on the DVD. The first part covers the hardware design in some detail, including the communication protocol between the two processors. The second part covers programming the device.

This is more about the development environment and use of the source code libraries provided; you will have to look elsewhere for information on actually learning how to program either in C for the PIC or Spin for the Propeller. Fortunately, there are several good books available, although those experienced with programming microcontrollers in general will find plenty of information on the DVD.

All the software tools and source code libraries are provided, and as this is a very new product, the information is quite up to date. The user manual is available for download and is well worth a read. A link to it is provided at the end of the article.

The DVD contains everything you will need to start developing software for both processors, plus much, much more. Datasheets, 30-year-old magazine articles, compilers, software tools, even CAD programs to help you design your own PCBs. All the programs supplied are freely available versions, and are perfectly suited for use with the Chameleon – they are not limited cut-down versions.

Conclusion

We love the way that the propeller chip has encouraged the re-implementation of 1980s video arcade games such as Defender and Donkey Kong. Not just for the nostalgia, but for the inspiration being given to people coming into the area of software development. The process of developing some of these games has been discussed very openly on the Parallax forums as the games were being created, to the great astonishment of those observing. It's very motivational, and is bound to inspire others to try their hand at their own games.

The Chameleon is an excellent low cost tool that will provide many, many hours of experimentation. If you are a novice with microcontrollers, however, you should be prepared for a lot of work – but the effort will be worth it, and there are plenty of existing games available for download to inspire you along the way.

Having hopefully whetted your appetite for the Propeller chip, next month we start building up our own hardware design, and build on it month-by-month for the next three articles.

References

User Manual: **www.chameleon-dev.com/pub/uploads/Main/cham_pic_user_manual_v1.pdf**

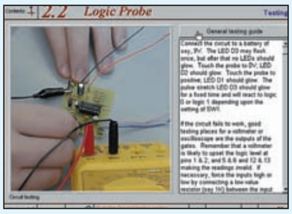
Nurve Networks: **www.xgamestation.com**

FOR CONTACT DETAILS SEE NURVE'S ADVERT IN THIS ISSUE – PAGE 33

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

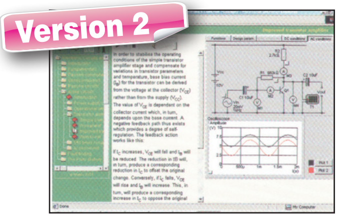


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

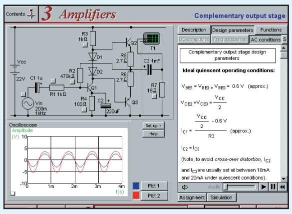


Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits. Active Circuits***. *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

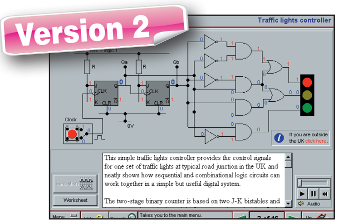


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: ***Fundamentals*** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). ***Op Amps*** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. ***Amplifiers*** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). ***Filters*** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). ***Oscillators*** – 6 sections from Positive Feedback to Crystal Oscillators. ***Systems*** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0



Virtual laboratory - Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

ANALOGUE FILTERS

Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	**£45**	**inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99**	**plus VAT**
Institutional 10 user (Network Licence)	**£249**	**plus VAT**
Site licence	**£499**	**plus VAT**

(UK and EU customers add VAT at 17.5% to 'plus VAT' prices)

PICmicro TUTORIALS AND PROGRAMMING

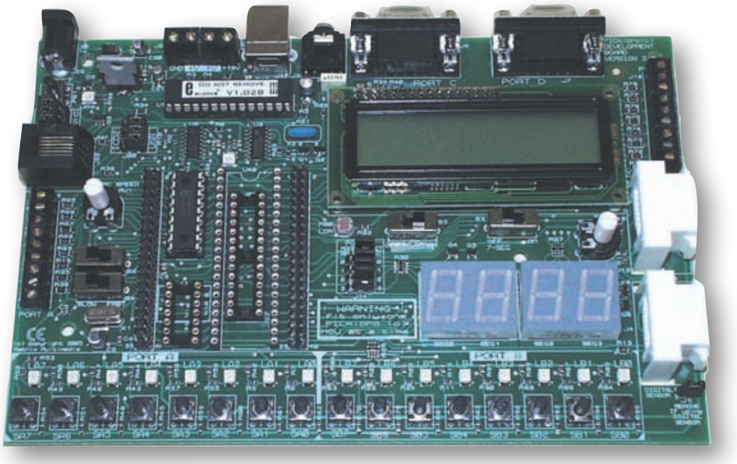
HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual LEDs, quad 7-segment display and alphanumeric LCD display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)



£158 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

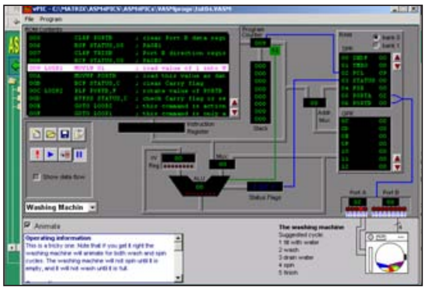
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

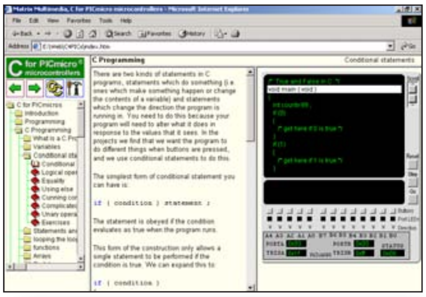


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

FREE with Flowcode V4 (student and institutional versions) ECIO board – a 28-pin reprogrammable microcontroller.

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● 16-bit arithmetic strings and string manipulation ● pulse width modulation ● I2C. New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)

PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

Hobbyist/Student	£45	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional/Professional 10 user (Network Licence)	£350	plus VAT
Site Licence	£699	plus VAT
Flowcode Institutional (Schools/HE/FE/Industry)	£149	plus VAT
Flowcode 10 user (Network Licence)	£399	plus VAT
Flowcode Site Licence	£799	plus VAT

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SPECIAL PACKAGE OFFER

TINA Pro V7 (Basic) + Flowcode V3 (Hobbyist/Student)

TINA Analogue, Digital, Symbolic, RF, MCU and Mixed-Mode Circuit Simulation, Testing and PCB Design

£68.00 inc. VAT and p&p

TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

Customise presentations using TINA's advanced drawing tools to control text, fonts, axes, line width, colour and layout. You can create, and print documents directly inside TINA or cut and paste your results into your favourite word- procesing or DTP package.

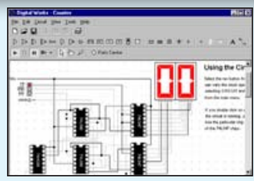
TINA includes the following Virtual Instruments: Oscilloscope, Function Generator, Multimeter, Signal Analyser/Bode Plotter, Network Analyser, Spectrum Analyser, Logic Analyser, Digital Signal Generator, XY Recorder.

***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

Get TINA + Flowcode for a total of just £68, including VAT and postage.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

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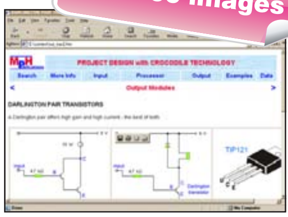

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ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 jpg images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

Now contains Irfan View image software for Windows, with quick-start notes included.

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Note: The software on each version is the same, only the licence for use varies.

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Max's Cool Beans

By Max The Magnificent

I'm ready for India, but is India ready for me?

As I pen these words, I am bouncing up and down with excitement performing my 'happy dance' (it's not a pretty sight) because I just booked my flight to attend *ESC India 2010*, which is to be held on 21 to 23 July in the historic city of Bangalore (also known as Bengaluru) (visit **www.ESC-India.com for more details**).

Mysterious, exotic, fragrant, spicy... but enough about me, let's talk about India! A quick visit to Wikipedia informs me that Bangalore, which is known as the 'Silicon Valley of India', is the capital of the Indian state of Karnataka. Also, it's the third largest city in India.

I really cannot begin to tell you how excited I am. This is going to be my first trip to India, and based on the tales told to me by Indian friends who were born there, and other friends who have visited, I know enough to expect a multi-faceted experience – from extreme poverty to magnificence and opulence – but at the moment my 'knee-jerk' reaction is to visualise India's rich history and incredible architectures.

In addition to all of the local expert speakers, I'm going to be in the company of four American heroes in embedded space ('where no one can hear you scream'): Mike Barr (Netrino), Robert Oshana (Freescale Semiconductor), Gary Stringham (Gary Stringham and Associates), and Bob Zeidman (SAFE Corporation).

Comic relief

Truth to tell, these guys are so good that I'm wondering why I was invited; maybe I'm the warm up act and the comic relief for everyone to laugh at.

Be that as it may, on Wednesday, 21 July, I'll be giving an all-day presentation introducing the hardware domain to firmware/software developers. Intended for computer scientists and embedded software developers, this session will provide an intuitive understanding of the underlying hardware these folks interact with via their device driver code.

Among many other topics, I'm going to waffle on about stuff like analogue versus digital (including A/D and D/A conversion); real-world sensors (optical encoders, accelerometers, pressure sensors); different types of numerical representations (sign magnitude vs signed binary, fixed vs floating point, and the use of binary-coded decimal (BCD) for certain applications); microprocessors versus microcontrollers. Plus, what do we mean by ASIC, ASSP, SoC, FPGA (can you have an ASIC that is also an SoC, for example)?; programmable logic (PLDs, CPLDs, FPGAs); memory ICs (Flash vs EEPROM; SRAM vs DRAM; the underlying concepts of DDR, DDR2, DDR3; potential future memory technologies like phase-change devices). Printed circuit board technologies (multi-layer boards; lead-through hole vs surface mount technology; high-density interconnect and micro-via technologies) ... and so forth.

DON'T PANIC! The idea of this presentation is not to delve so deep into the fiddly details of hardware and hardware design that it makes one's brain ache and one's eyes water; instead, it's to familiarise software folks with the concepts and terms used by the hardware guys so as to facilitate communication between the two domains...

And then on Friday 23 July, I'll be giving a 75-minute lecture titled *How to Choose the Right FPGA for Your Embedded Application*. In this session we will discuss a wide range of considerations that may affect the FPGA selection process. We'll start with a high-level view of the various underlying FPGA fabrics (antifuse-based, FLASH-based, and SRAM based). Also the availability/use of hard IP blocks versus their soft IP counterparts implemented in programmable fabric (including hard and soft µP/µC cores). Of course, we will also consider the various FPGA offerings from different vendors, including the availability of different µP/µC cores, ultra-low-power FPGA fabrics, asynchronous FPGA fabrics, mixed-signal FPGA fabrics, programmable analogue fabrics, radiation-tolerant FPGA fabrics, and ... the list goes on. This really is going to be quite exciting, because I happen to know all sorts of secrets (from well-known companies and from companies that are still in deep stealth mode) that have not yet been announced.

Meanwhile, I'm revisiting my favorite 'Bolywood' films, including two of my all-time favorites: *Bride and Prejudice* and *Monsoon Wedding*. Actually, now I come to think about it, I had better start practising my dance moves, just in case I'm caught up in one of the spontaneous street dances and songs that – I am led to believe by these films – happen all of the time in India (note to self: 'don't forget to pack my dancing shoes').

I will of course be taking lots of photos and creating some YouTube videos and I will tell you all about my experiences upon my return; watch this space!

I want a jet pack!

But wait, there's more! I'm sure you've seen the old James Bond type jet packs – the ones that look amazingly exciting and tremendously dangerous – and we'd all like to try one once, but we know the novelty would quickly wear off because they really aren't practical ... UNTIL NOW!

When I hear the term 'Jet Pack', I immediately think of the 1960s-type units with the two pipes hanging out of either side. As I recall, in addition to generating enough noise to deafen you, the jet engine in these things could last only around 30 seconds to one minute, which made them impractical for anything except the occasional sequence in a James Bond film.

However, I just heard about a forthcoming offering from the Martin Aircraft Company in Christchurch, New Zealand (if you check out their website at **www.martinjetpack.com** you'll see a bunch of cool photos and videos and techno stuff). This little beauty requires only five gallons of the same premium gasoline used in automobiles. The 200 horsepower, dual-propeller pack can fly for 30 miles in 30 minutes on a full tank of fuel, with a top speed of 60mph.

With regard to safety, if the user 'lets go' of the controls and goes 'hands free', the aircraft stops and maintains a stable hover (the machine is also equipped with a ballistic parachute in the unlikely event that the engine cuts out for any reason.

Do you have to go to pilot school to fly one of these beasts? Well, the Martin Jetpack complies with the FAA Part 103

Ultralight Regulations, and the Ultralight class does not require an FAA-recognised pilot's license. Having said this, it would be extremely silly for anyone to attempt to fly anything like this without professional instruction, and the Martin Aircraft Company has devised a training programme which all owners are required to pass (they don't want to be sued).

Well, I don't know about you, but I would LOVE to own one of these little beauties. My office is only about 10 miles away from my home, but it takes me about 25 minutes to drive each way because of all the traffic (Huntsville is a booming town with lots of new folks moving in, and the infrastructure is struggling to keep up). Using one of these jet packs I could be at work in only five to 10 minutes.

Honestly, now I've seen this, when I'm driving back-and-forth to work I keep on looking at things like overhead wires thinking, 'I'd have to fly over those' and interesting buildings and suchlike thinking, 'I wonder what that would look like from above?'

Yes I know it would take more time to suit-up and then change clothes at the office, but that's the price one has to pay to be a trend-setter and leader of fashion. Of course, I don't currently have the $50,000 purchase price (and I don't expect to have it in my lifetime, unless ... that reminds me, I have to check the lottery tickets my wife and I purchased when we went to Nashville for Valentine's Day a couple of weeks ago) but if I did, I would be sorely tempted.

Until next time – have a good one!

Check out 'The Cool Beans Blog' at www.epemag.com

Catch up with Max and his up-to-date topical discussions

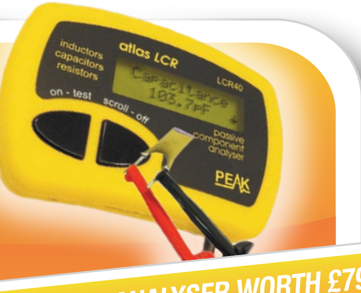
Up, up and away in my beautiful flying machine!

READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly



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★ LETTER OF THE MONTH ★

Antistatic precautions

Dear Editor

I read Robert Penfold's *Practically Speaking* feature (*EPE*, Mar'10), and would like to make it known that the resistive earthing cord for an anti-static wristband (or work mat for that matter) is an essential safety measure. The requirement is incorporated into the relevant British Standard (BS), and (in a commercial environment) must be tested periodically for compliance.

The reason is simple: far from worrying that being connected to the ring main's earth might give you a shock, the concern is that you might accidentally touch something that is live while you present a low-resistance path to earth – potentially lethal. To eliminate that risk there must be a resistance in the path low enough to dissipate static, but high enough to protect you from inadvertent electrocution – several megohms is sufficient for the task.

The BS does not allow for it, but in a non-commercial set up you could consider not connecting to earth (either mains or a water pipe) at all. With a conductive work mat and a wristband linked to the mat, any static will equalise to the local environment and any equipment handled on the mat will be safe (just make sure unprotected components arrive or leave in suitable packaging), and there will be even less personal risk. (No mains-powered kit mind, but that applies anyway.)

I have already mentioned the need to test one's anti-static measures regularly – ideally every time you are about to rely on them. In the commercial world (BS9000 and all that) this means calibrated test equipment and recorded compliance. The need for anti-static protection is no less for the amateur. Consider this, you are about to upgrade your PC with the latest processor and you don't want to fry your very expensive investment before you even turn the computer's power on. But how do you know your precautions are working? What's needed is a wristband tester – it sits on the mat and goes bleep (and lights an LED) when you touch it to complete the circuit. No bleep and you know the mat or the link through to the wristband and you is either open circuit (too high a resistance) or too low a resistance to be safe (the LEDs tell you which), and no LEDs lit tells you the battery is too low for a good reading. An *EPE* project perhaps?

Ken Wood

An excellent suggestion Ken – many of us are too often too cavalier about static protection, and this is a much welcome reminder to be both personally safe and to look after expensive components.

Project ideas

Well, I have to say EPE *readers have certainly responded creatively to my call for project ideas – thank you. We do take these ideas seriously, but do remember we have to plan many months in advance, and it may be some time before we are able to take advantage of your suggestions. In the meantime, here are some examples of your fertile minds!*

Matt Pulzer (Editor)

MIDI

Dear Editor

I'm sure many of your readers, like me, are interested in music as well as electronics, and one of the things that connects these two subjects is MIDI. Commercially available units such as MIDI merge or filter units are generally expensive, and I'd like to be able to build my own. Although I have experience in using MIDI and PICs, I have nowhere near enough knowledge needed to start building my own kit. The sort of things I'd like to be able to do are filtering out certain MIDI messages like program change or to be able to insert certain MIDI messages between two devices at the press of a button.

Some years ago Robert Penfold published some information on this subject, but that was for a PIC 16F84 if I remember rightly, and I'm sure some of the more modern PICs would be much more up to the job.

So, how about a tutorial on using PICs for MIDI, and maybe a couple of projects?

Dave Schuster, by email

Robert replies: I think that the PIC/MIDI designs I had published in EPE used the PIC chip to do all the MIDI encoding and decoding. Things are much easier with a PIC that has a built-in RS232C interface, since MIDI uses a slight variation on the normal RS232C scheme of things. All the PIC has to do is some (mostly) fairly basic processing, plus a bit of reading from and writing to the serial port. All you need is a PIC circuit with the MIDI interface hardware, some switches to control the gadget, and preferably some sort of display to provide status information. In normal computer fashion, the software then determines the function of the gadget (eg, filter or harmoniser).

I did produce the barebones setup some years ago, but did not pursue it further at that stage. I will see if I can resurrect this unit and develop it into a proper project.

Direct injection box for guitars

Dear Editor

The *Editorial* in the Mar'10 edition of *EPE* has prompted me to email you with a suggestion for a construction project. How about a design for a DI (direct injection) box for interfacing a guitar to an amplifier's microphone input – active or passive would be fine.

Keep up the excellent work at *EPE*.

Chris Hinchcliffe

Any contemporary Leo Fenders or Les Pauls out there who can help?!

C for PICs and GPS interfacing

Dear Editor

This is in response to your *Editorial* in the March 2010 magazine asking for ideas for content.

First, the much-aired subject of C for PICs – a lot of information exists on the web, but what I would like to see is a comprehensive series on similar lines to the brilliant PIC tutorials produced by John Becker. These could use MPLAB and the free C18 compiler and start from scratch. Turn an LED on and off, then introduce peripherals and C as you go along. You can't beat learning by practise!

Second, you have in the past published a couple of GPS projects. How about one showing how to interface a GPS device to Google Earth or Google Maps to show the unit's real-time position? Not simple, but you did ask.

Thanks for a brilliant magazine by the way. I'm not keen on some of the *Silicon Chip* projects, particularly the car mod ones, but I'm sure they have their fans.

I enjoyed the *Teach-In 2010* series on ladder logic and in particular Mike Hibbett's *PIC 'n Mix* articles.

Keep up the good work.

Dave Squibb

I do like the GPS suggestion, implemented in C… obviously! We do understand that not every project will please everyone, but judging by PCB sales, the automotive projects are very popular.

Ideas galore!

Dear Editor

First, I would like to say how much I enjoy my subscription to *EPE*, even though I am mostly an armchair enthusiast without much spare time. However, your call for ideas prompted this email, so here goes...

1) 'Wireless' RS232 lead – in Feb 2010, Robert Penfold discussed a USB-to-RS232 interface, and this touched on something I have been thinking about for a long time. I often work in factory environments, 'talking' to old devices with an RS232 link from my laptop. I really wish I could plug a wireless RS232 lead in so that I could work a safe distance away from plant, maybe where there is power for my laptop, or its quieter, or the panel door does not have to be kept open exposing live electrics.

I was thinking in terms of a WiFi USB dongle that could plug into a USB to RS232 adaptor or Bluetooth or even infrared, and then rely on the services built into my laptop for the other end. Typical baud rates are 9600, but sometimes as high as 38400.

There are devices on eBay for £50, but these seem designed for PC-to-PC interfacing. A typical industrial device often has an opto-isolated RS232 output that needs power from the connecting PC RTS lines, so a wireless lead would need to have the option of battery power if it couldn't use the control lines. USB WiFi and Bluetooth dongles for PCs are cheap, which makes this frustrating.

2) Following on from the above, a PIC project of some sort to convert RS232 to Ethernet, and vice versa.

3) A GSM signal booster would be most welcome. I have experimented with homemade Yagi antennae for improving GSM reception in rural areas using coat hanger wire and firework rocket sticks, but while the directional receiving end works, I don't know how to retransmit it to some sort of cradle for my mobile phone. If there is little signal the phone battery goes flat overnight. Maybe a GSM reception meter for locating where to leave your phone overnight?

4) DC kWh meter – solar panels are all DC-based devices, it would be good to have a measurement of DC power generated or used by battery systems that doesn't use too much power itself.

5) A data logger that doesn't require connection to a PC to capture and store data – leave it on site and return to download the data later. Could an old iPod be made into a data logger?

6) A project for the excellent *Recycle It!* articles. Those cheap LED solar lights that were all the rage a few years ago and are now all dud at the bottom of everyone's garden. Can they be revived with a bit of proper circuitry and a better battery?

7) An article on opto-isolator circuits and the protection of real-word project input/outputs – I guess this has probably been done before.

8) A PIC project to read GPS data from a Garmin or TomTom device, and then send an SMS text of the location at preset intervals or changes in location via an old mobile phone or AT commands. The receiving end is another PIC connected to another old phone that takes the SMS and converts it to a Google Earth KML file that allows real-time web tracking of position.

This would be ideal for charity-sponsored runs. The receiving end could be done in software with a nice add-on of some sort of online SMS text receiving to email forwarding service.

9) A *Recycle It!* article on other uses for some of the many sensors found in modern cars – could a dashboard LED display and temperature sensor be used to make a temperature gauge? Could tachometers and crank sensors be used to display wind speed, or fuel gauges the wind direction?

10) Remote control keypad – many devices have a standard ribbon-cable-connected dumb keypad. Could a PIC circuit intercept this ribbon cable, and then allow remote key presses via the Internet? Ideal for repeated testing of key presses on devices with a stored script of keys.

I think that's enough... back to my armchair with *EPE*.

Alastair Kinross

A most impressive collection of ideas Alastair, it's no surprise you work in an engineering environment. Your armchair certainly seems to be the perfect spot for your imagination.

'Uniting two nations separated by a common language!'

Dear Editor

I appreciated the *Editorial* in the Mar'10 issue. Back in Jul 2008, I started receiving the electronic version of your magazine. It saddens me that I have to go outside of the USA for circuit ideas, but I do appreciate that you're still here! (I also receive *Nuts & Volts* online.)

I've become a very strong proponent for the PICAXE chip, and like the fact that it uses the BASIC language. I know four languages, but BASIC is easy to program and learn. I hope to work with *EPE* and/or *Nuts & Volts* and push out a circuit occasionally. I also receive updates when MAXIM releases new chips, and would like to talk about those as well.

I'm 62, and was forced to retire in autumn 2004. In 2008, I discovered the PICAXE, and after collecting parts for a year, I'm ready to dig in and see what I can come up with. I would then like to pass on these projects to your readers, and to have the satisfaction of seeing them published.

What I'd like to see in *EPE* is:

1) PICAXE circuits, (you knew that was coming!)
2) Electronic circuits for model railroading
3) HHO and EFIE circuits to make cars more efficient
4) More green circuits – windmills, solar, inverters, batteries and controller circuits (can you smell the PIC projects this will bring?)

On a different subject, I have created a page that shows the difference between how engineers in the UK name components compared to what we call them in the US. I felt this was vital, especially for new readers, so that they get a well-rounded start in electronics. The relevant page is at: **http://elecurls.tripod.com/Euro_vs_USA.htm**.

I would appreciate it if readers could could help me fill in the page's '? gaps ?'. I believe I have the only page like this. (I researched the contents using multiple search engines, and never saw one like it.) Also, I'd like to invite readers to visit my main page: **http://elecurls.tripod.com**.

I have told many friends about your magazine, so I hope you get new subscribers from my message.

Teddy Mieske, USA, by email

Many thanks for your letter Teddy, and, of course, your interesting ideas and suggestions. We have carried a few projects based on the PICAXE range, and I would be open to offers for more!

I agree, model railways are a most fruitful opportunity for imaginative projects, and I would be interested to hear what you have in mind.

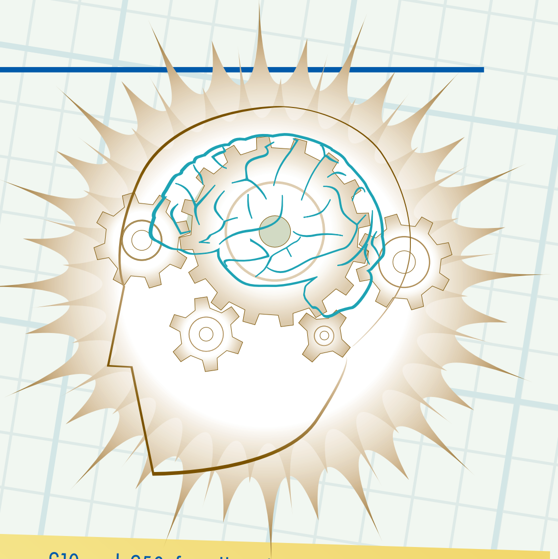
While we support the idea of 'green' projects in principle, in practice the problem is not so much the electronic engineering as the mechanical. I would welcome an original project for wind power, but they do require a windmill/wind turbine! – which is not an easy thing to build.

Last, but not least, thanks for your 'translation' page, a most useful website.

Best wishes and well done for spreading the word about EPE *among your friends in the States.*

Ingenuity Unlimited

Our regular round-up of readers' own circuits



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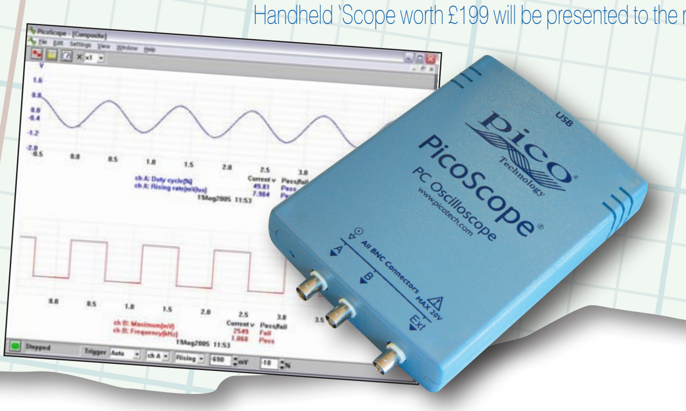


We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas must be the reader's own work and **must not have been published or submitted for publication elsewhere.**

The circuits shown have NOT been proven by us. **Ingenuity Unlimited** is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and include a full circuit diagram showing all component values. **Please draw all circuit schematics as clearly as possible.**

Send your circuit ideas to: Ingenuity Unlimited, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Email: editorial@epemag.wimborne.co.uk.

Your ideas could earn you some cash **and a prize** !

Super Simple Sonar – *Sound bite*

The circuit of Fig. 1 represents a 'super simple' 40kHz ultrasonic sonar. Sonar stands for SOund NAvigation Ranging, a technique used to determine the distance, and often the direction of objects by acoustic means.

The sonar described here relies on the principle of acoustic feedback. Rather than using the more usual method of transmitting a signal, which is 'listened for' by a receiver, it breaks into oscillation when a 40kHz ultrasonic transmitter/receiver pair come within range of each other – either in direct line-of-sight, or where sound is reflected off a surface. In direct line-of-sight, the circuit will break into oscillation at a metre's distance (eg, where the transmitter/receiver pair are positioned at opposite sides of a door which opens) – or it will break into oscillation near a reflective surface, at half a metre's distance (eg, where a car approaches a wall).

Circuit details

IC1 is a sensitive amplifier, the gain of which is controlled by capacitor C2. Transducers RX1 and TX1 are a 40kHz ultrasonic transmitter/receiver pair. The receiver, RX1, may be wired to IC1 without any additional electronics due to light internal biasing of IC1's inputs. Although this is an audio IC, it will easily operate at 40kHz – in fact up to 1MHz and beyond.

Capacitor C3 is necessary to limit output current, and also blocks DC. This is followed by a simple diode pump, so that the voltage rises across C4 when the circuit oscillates, switching MOSFET TR1. While I have shown TR1 switching LED1, it and R2 may be replaced by a 12V reed relay if desired.

Current consumption is a modest 5mA on standby, due to the fact that the circuit is dormant until it breaks into oscillation. Current consumption rises to 20mA when TR1 switches and LED1 illiminates. When the circuit is first switched on, LED1 should briefly illuminate and extinguish. If it does not extinguish, then RX1 and TX1 are likely positioned too close to one another. Start by mounting them both on the same surface, about 15cm apart, both pointing away from the surface – then move them as close together as possible without illuminating LED1.

Transducers RX1 and TX1 may be replaced by identical piezo sounders (discs mounted in plastic housings, without internal electronics). In this case, the resonant frequency will be much lower, and audible. The circuit from diode D1 onwards may then be removed, if only sound and no switching is required. The author's experiments indicated that this principle would work at ten times the distance with more complex electronics.

Thomas Scarborough, Cape Town, South Africa

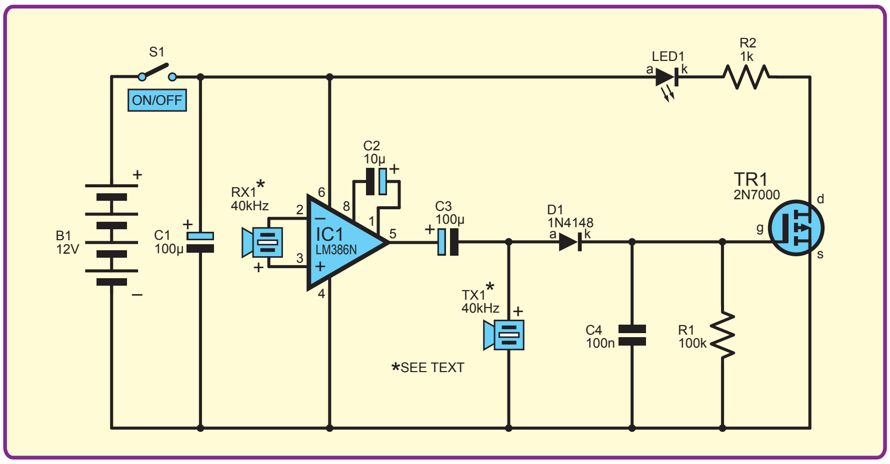


Fig.1. Complete circuit diagram for the Super Simple Sonar

LED Flash-Lite – *Ultra-simple single-cell LED torch*

It's called the Flash-Lite because it flashes an LED and it's very 'lite' on components. I reasoned that most small flashlights are rarely needed to supply more than about one minute of light.

This must be the simplest possible circuit for stepping-up a single battery (cell) to drive a LED. Instead of an electronic DC-DC converter, a DPCO momentary-action pushbutton switch is used to charge a capacitor and then switch it into series with the battery, giving a voltage boost. Of course, I could have used more batteries, but where's the fun in that?

Actually the capacitor is a 1F supercapacitor (that's one whole farad!) also known as a 'double-layer capacitor' (Maplin part no. NO3CQ). In the prototype circuit (Fig.2) it drives the red LED for about 90 seconds, with a five-minute recharge afterwards.

There is no need for an on-off switch as the supercap draws infinitesimal current once it has charged. If you check the circuit you will see that it can be wired entirely onto the solder tags of the switch. No PCB is needed.

In my final build I used a 3V lithium cell (CR123) and an Agilight 6000mCd white LED (Maplin part no. N21BY). If you reduce the resistor you can get a brighter flash, for a shorter duration.

Walter Gray
Via email

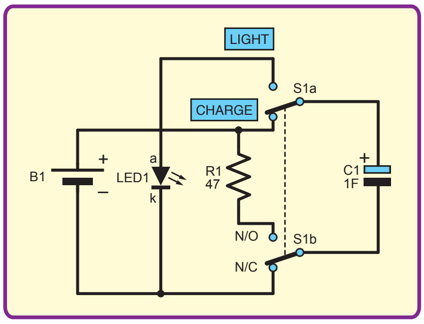


Fig.2. Complete circuit diagram for the LED Flash-Lite

Overcurrent Trip – *No more blown fuses*

While experimenting with a circuit, it occurred to me that blowing fuses was both annoying and inconvenient.

What was required was something that would switch off the power supply as quickly as possible if the current went above a preset limit; the result, an add-on overcurrent trip, is presented here.

The heart of the circuit is a set-reset flip-flop, comprising TR1, TR2 and resistors R1 to R4. The SR flip-flop is bistable, so that only one of the two transistors can be switched on at any one time, the other being switched off.

The TR2 collector is connected to the gate of a large power FET, which is used as a switch, switching on or off the output of the trip current.

All the current from the power supply to the load goes through resistor R7, causing a voltage drop accross it which is fed via R8 to the base of TR3. If this reaches about 0.5V, TR3 will turn on and connect the base of TR1, via R5, to the negative supply line. This will cause TR1 to turn on, TR2 to turn off and the voltage across R4 to go to zero volts, turning off TR4 and the current to the load.

The circuit may be reset by pushing the reset button S1. This causes the base of TR2 to connect momentarily to ground potential via R6. This swithces on TR2 and resets the trip circuit.

A red LED is included in TR1's collector supply, and a green LED in the supply to TR2. The red LED will light if the circuit trips, and the green LED will light if the circuit is supplying power to the test load.

For the current to trip at 120mA, use a value for 3.9Ω for R7, and for 5A a value of 0.1Ω is required. I have made two of these circuits, one of which required 0.49V across R7, and the other 0.52V for the current to trip.

To test the trip current, a test rig, shown in Fig.3, was constructed to act as a load. A large power transistor (I used a 2N3055) is used for TR5. The potentiometer is slowly turned so that the base voltage increases, and the transistor takes more current, until the circuit trips.

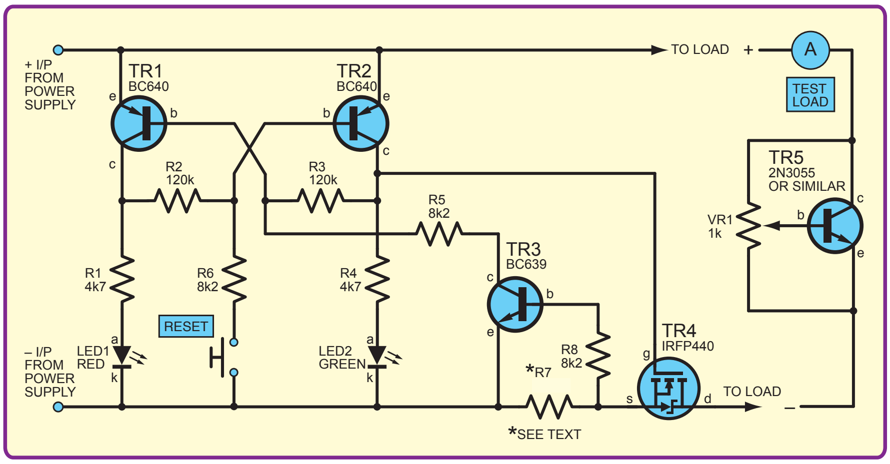


Fig.3. Complete circuit diagram for the Overcurrent Trip

TR4 may well need a heatsink, and the test load transistor TR5 may need one if you use it for more than a few seconds. Calculate the power losses in R7. With a load current of 5A then R7 will dissipate 2.5W. Be aware of the voltage drop across R7, which will affect the output voltage and may affect your earth arrangements.

This circuit is designed for **only small supply voltages**; 12V is not a problem, but using it on 24V or 36V will exceed the gate/source ratings of the FET and steps would have to be taken to prevent this. **It is NOT a replacement for safety devices**.

Ned Stephens, Lancashire

Net Work

Alan Winstanley

Cometh the hour, cometh the…

As a principle in life, I usually find that the Yorkshire maxim of 'hear all, see all, say now't' keeps me out of trouble, but one event that failed to register on my personal radar was the passing by of a Google camera car which glided silently past my house one summer's day last year. Fortunately, for my online presence, I had just mown the lawn.

Over the last two years the gradual but unstoppable progress of Google's fleet of camera cars seems to have been forgotten about. Integrating seamlessly into Google Maps, Street View is their 3D rolling presentation offering a motorist's-eye instantaneous snapshot of life not only in Britain, but across much of Europe. Starting with major cities, the length and breadth of the country has been snapped, recorded, digitised and stitched together into a panorama. Even obscure little country lanes and villages, including my own, did not escape the lenses of Google's camera cars. At least my front lawn looks decent.

Earlier this year, the shutters in Google Street View were suddenly thrown open to reveal pretty much every nook and cranny of our country (or at least the public ones that were accessible by car). As Google says, much more imagery of Great Britain and Northern Ireland is now online than ever before. It has come as an extraordinary surprise to find much of England suddenly laid bare this way, and the same is true of some of Western Europe as well as Japan, Australia and New Zealand.

… little yellow man symbol

Users of Google Maps will know of the yellow stick-man icon (dubbed 'Pegman' by Google) that appears on the left-hand side of the map window. Drag the icon over the map and any roads that have been digitised for Street View will turn blue. Release Pegman onto a blue-lined avenue and Street View launches at pavement level. You could then pan the view or click through to the next waypoint (highlighted by a scalable elipse). Its habit of nosediving into tarmac level before crashing out to aerial view again is distracting, but the way in which Street View brings a snapshot of the world to your screen is unsurpassed. More instructions for use can be found at **www.google.co.uk/help/maps/streetview/**.

Until recently, coverage of our isle was patchy at best, with only a handful of towns and cities available, but Google's contractors have pulled off the truly astonishing feat of capturing and recording the country at street level for displaying in Street View. Suddenly, and without any fanfare, Google has soft-launched the rollout of the entire Street View coverage across Britain and beyond.

Last year, when the privacy implications of this photorealistic mapping marathon first began to sink in, there was an instant negative media storm (see *Net Work* June 2009). Google clung doggedly to its slightly disingenuous position, namely that it is merely photographing public roads and not private ones and there is no law against it anyway. Perhaps the previous media furore is why the latest expansion phase of Street View has slipped quietly into view: having softened us up, the feeling of shock of our world being laid bare will have subsided.

In some quarters, there has been outrage at the very thought of Google cameras peeping over the fencing and sticking voyeuristic vistas all over the Internet for the world to see. Many, including the author, have shrugged it off as a sign of the inevitable march of progress; even if my residential address (with freshly mown lawn) did feature in Google Maps Street View, it isn't as though the whole world is suddenly going to beat a path to my own front door as opposed to 20 million others in Great Britain.

Getting street wise

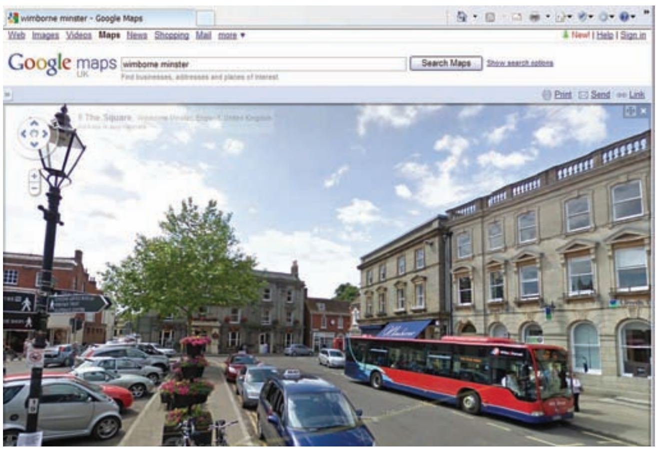
Street View is getting set to become as universal a tool as Google Search already is. It shows the local fire brigade what a place looks like so they can arrive better prepared. Roofing contractors or aerial riggers can maybe see what's in store for them at a potential customer location; maybe they can offer to quote customers without having to visit. Anyone planning a car journey can travel more confidently with a better idea of what lies ahead: or by emailing a link, visitors can be shown in advance what their destination looks like.

The frontiers of technology cannot be rolled back, it seems, and it is only a matter of time and bandwidth before photorealistic Street View-type presentations find their way into, say, realtime car satnav systems. Street View will be better accessible via a mobile phone, which chimes with the thrust adopted by Google towards Local Search. If you want to find a pizza or a coffee house, just Google for it on your phone. Traffic and satnav 'gadgets' for mobile phones are, of course, already available from TomTom. Aided by GPS on a mobile phone, Google search and Street View will direct customers straight through the doors of bricks and mortar establishments.

The ever-closer integration of data mined by Google gives rise to some nagging doubts that go beyond the surprise of finding one's garden depicted in the panorama. As we dig more deeply and stare at those Street View scenes, Google tells us more about people, neighbourhoods, locations, bus and train routes (and timetables), photos, business details, customer reviews and more. Google USA is even integrating local traffic conditions into Google Maps.

The full implications of Google's revolution have yet to be realised, least of all by the data subjects (ourselves) whose presences are laid bare for anyone to see. Doubtless, all manner of social and economic data (house prices, crime rates) will eventually become more accessible in the same way. We are all perhaps being wrong-footed by the sheer pace of Google's latest innovations. Great care will be needed to understand precisely what information Google does display online, as the practical implications of Google's inquisitiveness become more clear. Meantime, let's all have a good nosey around.

You can Email me at **alan@epemag.demon.co.uk**



Data bus – how street life bustles at The Square in our own town of Wimborne in Dorset. Find more on **maps.google.co.uk**.

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Mike Tooley

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COMPUTING AND ROBOTICS

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and home editions.

The book was written with the non-expert, busy person in mind. it explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

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MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

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Covers the Vision command system

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

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R.A Penfold

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages + CD-ROM **Order code BP542** **£8.99**

ROBOT BUILDERS COOKBOOK
Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

366 pages **Order code NE46** **£26.00**

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation.

Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems; Temperature; Light; Position and motion; Force, pressure and flow. Part 2 – Interfacing; Number systems; Computer architecture; Assembly language; Interfacing; A to D and D to A conversions; Data communications; Programmable logic controllers; Data acquisition project. Part 3 – Signal processing; Transfer function; Active filters; Instrumentation amplifier; Noise; Digital signal processing.

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THEORY AND REFERENCE

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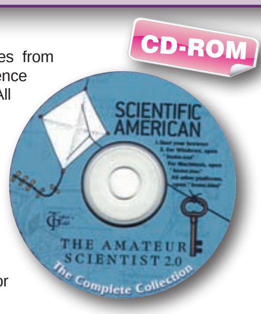

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OSCILLOSCOPES – FIFTH EDITION
Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.

This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.

The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscillocopes work (1): the CRT; How oscillocopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages — **Order code NE37** — **£36.99**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money

In most applications of electronics, test instruments are essential for checking the performance of a system or for diagnosing faults in operation, and so it is important for engineers, technicians, students and hobbyists to understand how the basic test instruments work and how they can be used.

The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.

206 pages — **Order code PC109** — **£9.95**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

228 pages — **Order code NE35** — **£36.99**

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FULL COLOUR COMPUTING BOOKS

HOW TO FIX YOUR PC PROBLEMS — **R.A. Penfold**

What do you do when your laptop or desktop stops working properly. Do you panic, try to find the answer on the page of fault finding tips you may find at the back of the manufacturers manual. Or do you spend hours trying to get through to a telephone helpline or waste even more time waiting for an email reply from a helpdesk.

Well help is now at hand! This book will assist you in identifying the type of problem, whether it's hardware, software or a peripheral that is playing up? Once the fault has been identified, the book will then show you how to go about fixing it. This book uses plain English and avoids technical jargon wherever possible. It is also written in a practical and friendly manner and is logically arranged for easy reference.

The book is divided into four main sections and among the many topics covered are: Common problems with Windows Vista operating system not covered in other chapters. Also covers to a lesser extent Windows XP problems. Sorting out problems with ports, peripherals and leads. Also covers device drivers software and using monitoring software. Common problems with hard disc drives including partitioning and formatting a new drive. Using system restore and recovering files. Also covers CD-ROM and Flash drives. Common problems with sound and video, including getting a multi-speaker system set up correctly.

An extremely useful addition to the library of all computer users, as you never know when a fault may occur!

Printed in full colour on high quality non-refective paper

128 pages — **Order code BP705** — **£8.49**

AN INTRODUCTION TO WINDOWS VISTA — **P.R.M. Oliver and N. Kantarris**

If you have recently bought a new desktop or laptop it will almost certainly have Windows as its operating system. Windows Vista manages the available resource of a computer and also 'controls' the programs that run on it.

To get the most from your computer, it is important that you have a good understanding of Vista. This book will help you acheive just that. It is written in a friendly and practical way and is suitable for all age groups from youngsters to the older generation. It has been assumed that Vista is installed and running on your computer.

Among the numerous topics explained are: The Vista environment with its many windows. How to organise your files, folders and photos. How to use Internet Explorer for your web browsing. How to use Microsoft Mail for your emails. How to control your PC and keep it healthy. How to use Vista's Accessibility features if you have poor eye sight or difficulty in using the keyboard or mouse. And much more besides....

With the help of this book you will easily and enjoyably gain a better understanding of Microsoft's amazing Windows Vista operating system.

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COMPUTING WITH A LAPTOP FOR THE OLDER GENERATION — **R.A. Penfold**

Laptop computers have rapidly fallen in price, increased in specification and performance and become much lighter in weight. They can be used practically anywhere, then stored away out of sight. It is therefore, not surprising that laptop sales now far exceed those of desktop machines and that they are increasingly becoming the machine of choice for the older generation.

You may want to use your laptop as your main computer or as an extra machine. You may want to use your laptop on the move, at home, at work or on holiday. Whatever your specific requirements are, the friendly and practical approach of this book will help you to understand and get the most from your laptop PC in an easy and enjoyable way. It is written in plain English and wherever possible avoids technical jargon.

Among the many topics covered are: Choosing a laptop that suits your particular needs. Getting your new computer set up properly. Customising your computer so that it is optimised for your particular needs. Setting up and dealing with user accounts. Using the Windows 'Ease of Access Center'. Optimising the life and condition of your battery. Keeping the operating system and other software fully up-to-date. Troubleshooting common problems. Keeping your computer and data safe and secure. And much more besides...

Even though this book is written for the older generation, it is also suitable for anyone of any age who has a laptop or is thinking of buying one. It is written for computers that use Windows Vista as their operating system but much will still apply to Windows XP machines. Printed in full colour on high quality non-refective paper

120 pages — **Order code BP702** — **£8.49**

AN INTRODUCTION TO EXCEL SPREADSHEETS — **Jim Gatenby**

The practical and friendly approach of this book will help newcomers to easily learn and understand the basics of spreadsheets. This book is based on Microsoft's Excel 2007 spreadsheet, but much of the book will still apply to earlier versions of Excel. The book is written in plain English, avoiding technical and mathematical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Install the software. Use the exciting new features of Excel 2007. Create and use a spreadsheet. Enter, edit and format text, numbers and formulae. Insert and delete columns and rows. Save and print a spreadsheet. Present the information on a spreadsheet as a graph or chart. Manage and safeguard Excel files on disc. Use Excel as a simple database for names and addresses.

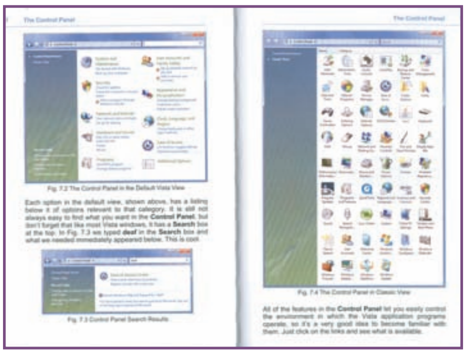
This book will help you to quickly gain confidence and get to grips with using spreadsheets. In fact, you will wonder how you ever managed without them.

Printed in full colour on high quality non-reflective paper.

118 pages — **Order code BP701** — **£8.49**

AN INTRODUCTION TO DIGITAL PHOTOGRAPHY WITH VISTA — **R.A. Penfold**

The friendly and practical approach of this book will help newcomers to digital photography and computing to easily learn the basics they will need when using a digital camera with a laptop or desktop PC. It is assumed that your PC uses Windows Vista, however, if it is a Windows XP machine the vast majority of this book will still apply. The book is written in plain English, avoiding technical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.



Among the many topics explained are how to: Understand the basic features of a digital camera. Transfer photographs from your digital camera to your computer. View your photographs. Save, sort and file your photographs. Manipulate, crop and carry out simple corrections to your photographs. Copy your photographs on to CD or DVD. Print your photographs. Share images with family and friends anywhere in the world by email or with an online album.

This book will help you quickly get to grips with, gain confidence and expand your horizons in the fascinating hobby of digital photography.

Printed in full colour on high quality non-reflective paper.

120 pages — **Order code BP700** — **£8.49**

PROJECT BUILDING

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

Temporarily out of print

BUILDING VALVE AMPLIFIERS
Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.
A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.
Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£29.00**

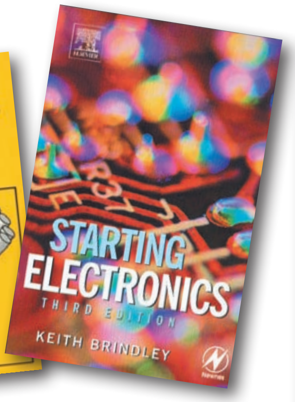
THEORY AND REFERENCE

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**



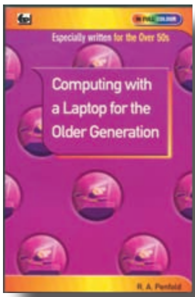
STARTING ELECTRONICS
Third Edition
Keith brindley

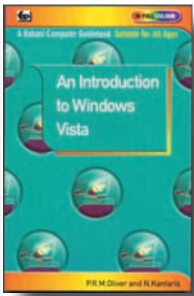
A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£13.99**





PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

HOW TO BUILD A COMPUTER
R.A. Penfold

To build your own computer is, actually, quite easy and does not require any special tools or skills. In fact, all that it requires is a screwdriver, pliers and some small spanners rather than a soldering iron! The parts required to build a computer are freely available and relatively inexpensive.
Obviously, a little technical knowledge is needed in order to buy the most suitable components, to connect everything together correctly and to set up the finished PC ready for use. This book will take you step-by-step through all the necessary procedures and is written in an easy to understand way. The latest hardware components are covered as is installing the Windows Vista operating system and troubleshooting.

320 pages **Order code BP592** **£8.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.
There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.
Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£5.45**

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NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

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A large number of older boards are listed on, and can be ordered from, our website.

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Knowledge of Atmel chips would be useful Work from home and I will pay all reasonable costs. Contact Roger at: info.emp@virgin.net Tel: 07850 854920

KITS, TOOLS, COMPONENTS. S.A.E. Catalogue. SIR-KIT ELECTRONICS, 52 Severn Road, Clacton, CO15 3RB, **http://sir-kit.webs.com**

VALVES AND ALLIED COMPONENTS IN STOCK. Phone for free list. Valves, books and magazines wanted. Geoff Davies (Radio), tel. 01788 574774.

EVERYDAY PRACTICAL ELECTRONICS

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PIC-BASED MUSICAL TUNING AID

No more tuning forks, as *EPE* gains perfect pitch! This clever and compact project will help you tune almost any musical instrument – acoustic or electronic. It can produce any note on the tempered musical scale (standard pitch) in any of the eight most commonly used octaves, with an accuracy of better than ±0.08%.

HOW TO SOLDER SMDs

We've all been there – you find the perfect circuit or project, just what you need, but then… 'oh no'… you need to solder SMDs. All too often we give up at this point – but now help is at hand. Jim Rowe shows how to painlessly solder these tiny components.

DSP MUSICOLOUR PART 2: PUTTING IT TOGETHER

Previously, we described the DSP Musicolour's circuit operation. Now it's time for its construction. As always, the description is thorough, comprehensive and lavishly illustrated.

WATER TANK LEVEL METER PART 3: TELEMETRY BASE STATION

In the concluding part of this series, we add the sophisticated base station. This will let you monitor water levels from a remote location, and even includes an option for electric pump control. This really is a must for gardeners who have their water metered.

RECYCLE IT! – MAKING USE OF OLD BREADMAKERS AND FAN HEATERS

Small consumer goods like breadmakers and fan heaters often pop up free of charge, and it's well worth pulling them apart for the good bits inside. Julian Edgar shows you what to salvage for next to nothing.

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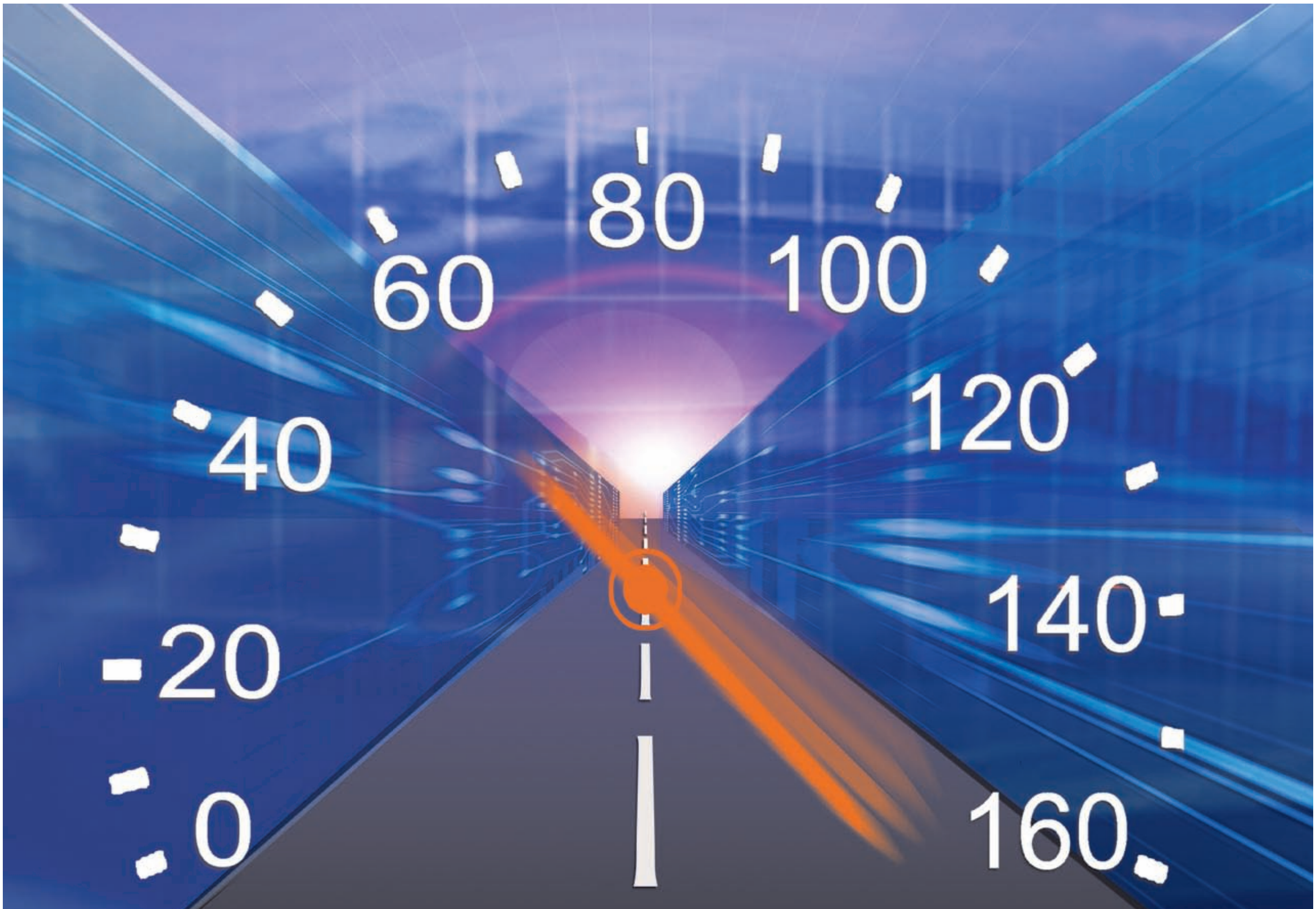
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